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EDITORIALS

Inspection of Front Ends

There is one part of the locomotive which usually requires attention out of all proportion to its importance; it is the front end. A great deal of thought has been given to the development of improved spark arresters, nozzles are fitted with care and petticoat pipes are securely braced. Yet in spite of these precautions many railroads find it advisable to inspect the front end at frequent intervals and oftentimes after every trip. The labor cost of loosening from 12 to 24 clamps holding the smokebox door, inspecting the front end and replacing the clamps is a very considerable item. Some roads have adopted improved types of spark arresters and lengthened the period between inspections, but other roads continue the practice of daily inspection regardless of the design of the front end. Possibly this is necessary under certain circumstances to guard against holes in the netting or displacement of draft appliances. If that is the case a new design of fastening for the smokebox door should be adopted. The present type was intended to be a semi-permanent fastening and it would not be difficult to devise an arrangement that would be far more convenient, where the door must be opened frequently.

Innovations in Car Design

One of the most notable developments in the railroad field during the past year has been the remarkable number and variety of new designs of cars that have been introduced. Of these probably the most important is the high-capacity equipment placed in service on the roads that handle coal from the mines to tidewater. The 120-ton cars of the Virginian Railway established a new record for freight equipment in regular service and have demonstrated the efficiency of such large units. By the use of these cars the Virginian has been enabled to increase train loads to as high as 17,250 tons. The 100-ton capacity cars of the Norfolk & Western are likewise noteworthy because of the unique design of six-wheel trucks and the high ratio of load to total weight.

Another radically different type of equipment that promises to effect a considerable saving for the railroads is the container car. Two designs differing somewhat in details are now in use and roads that handle a large amount of l.c.l. freight are experimenting with this system as a means of reducing loss and damage and cutting down the cost of handling package freight.

In passenger equipment the most important development has been in self-propelled cars. A number of automobile manufacturers are now engaged in perfecting small passenger cars propelled by gasolene engines. Recent trials indicate that the cars will be entirely successful for branch line service and will handle the business for a fraction of the cost of the ordinary train hauled by a steam locomotive. Among other notable innovations in passenger equipment brought out during the year may be mentioned tank cars for milk and cable loops for the prevention of telescoping.

This summary indicates that considerable progress has been made during the year, yet Henry Ford has criticized the design of cars quite severely. The only concrete suggestions that he has seen fit to offer thus far are the proposed use of alloy steel to reduce weight and wheels free to turn on the axles to eliminate friction in rounding curves. The railroad world is awaiting with interest the development of the "flivver freight car," as Mr. Ford's proposed design has already been named. Regardless of the success or failure of his design, it must be admitted that Mr. Ford has a clear realization of the possibilities of improved car equipment as a factor in reducing operating costs. The present tendency is toward refinement in car design, and if it continues, equipment built a few years hence will probably be radically different from what is considered standard practice today.

Why Grind Wheel Fits?

The question of grinding driving axle fits in wheel centers has been raised and it may be of advantage to consider some of the reasons why certain railroads follow this practice. The most important reason is that by using grinding machines, wheel fits can be made to within extremely close limits and accurate mounting pressures maintained. Moreover, it is the practice in some shops to grind the journals of new or unmounted axles, and time is saved by grinding the wheed fits at the same setting. Should a wheel-fit become rough in pressing out the axle, or for any other reason, grinding also offers a means of truing the rough parts in the shortest time and with the removal of a minimum amount of metal.

There is no objection to a ground wheel-fit on account of the smooth surfaces. The frictional resistance tending to hold a driving wheel on its axle is dependent far more on the pressure between the two surfaces than on the condition of those surfaces. The idea that a rough fit results in greater holding power is erroneous.

A rough fit is unreliable for either locomotive or car wheels, due to the fact that in mounting the wheel the rough places are ploughed down and the gage does not show accurately the pressure that holds the wheel. If this same wheel is dismounted and applied again there would be a considerable decrease in the tonnage registered. For example, if an 80,000-lb. capacity steel wheel is mounted at a pressure of 65 tons in the first case, the mounting pressure on the second application will be considerably less, possibly 55 or 58 tons, which is below the mounting pressure limit for this class of wheel. In other words, the effect of a rough wheel fit is to show a wheel mounting pressure larger than is really obtained. It follows directly from this that the smoothness, accuracy and close limits of an axle fit, as obtained by grinding, tends to provide a better control of wheel mounting pressures and thus reduce trouble from loose wheels.

Welding Firebox Seams

In comparing the present methods of doing repair work in railroad shops with those which commonly prevailed only a relatively few years ago, one of the most noticeable changes is the rapid extension of welding processes. Considering the large savings in time, labor and material that have been obtained, it is not surprising that it has been advocated and employed in places where its advisability is questionable.

Before undertaking a job of welding, the process to be employed must first be determined. Gas, electric and thermit welding each have distinct fields for which they are best suited, and the limitations of these fields are far better

understood today than ever before. After the process has been decided upon, the next thing to be considered is the preparation of the articles to be welded, for the whole process of the welding is often dependent upon the proper preparation before welding itself is started. Following the welding, the internal strains which may have been set up in the work must next be considered and the proper precautions taken to relieve or remove these stresses by after-annealing.

At the present time considerable welding is done in connection with locomotive boiler maintenance work. Much of this has been economical and thoroughly successful. However, the fact must not be overlooked that welding has in a number of cases been followed by serious accidents resulting in loss of life and sometimes in a complete wrecking of the locomotive. There is too much involved when the possibility of a boiler explosion is considered, to warrant taking any unnecessary risks involving its safety. A boiler failure following repairs by welding tends to bring the whole process of welding on boilers into disrepute, although there are places on boilers where welding is a perfectly proper procedure. One safe rule to follow is that recommended by the Bureau of Locomotive Inspection: Never weld around the crown sheet or combustion chamber of the firebox sheets where low water can possibly expose the sheets to steam and thus permit the welded portion to become unduly heated.

The Real Purpose of Shop Schedules

DURING the early stages of the development of shop scheduling and routing systems for use in railway repair shops, they were usually closely associated with some form of bonus or piece work system of wage payment. It is perhaps not surprising, therefore, that there is an impression in the minds of some railroad officers who were favorably inclined toward shop scheduling prior to the abolition of piece work, that such a system offers no advantages under a straight time basis of compensation, and, indeed, is likely to meet with opposition from the shop crafts as a means of speeding up labor.

No better evidence that these impressions are without foundation could be presented than will be found in the results obtained during the first year's experience with a shop scheduling system at the Milwaukee passenger car shop of the Chicago, Milwaukee & St. Paul, set forth elsewhere in this issue. Prior to the establishment of the shop scheduling system the average output during a period of nearly three years was slightly less than two cars a day. During the first year's operation under the system the output has averaged three cars a day, and less men have been employed than during the former period. The fact that the increased output has been obtained without friction between the management and the shop employees is ample demonstration that shop schedules, rather than being a measure aimed at speeding up the men, is a matter of concern only to the management for reducing the lost motion in the exercise of its own functions.

Indeed, it is reasonable to expect even better results from shop schedules under the hourly rate of wage payment than under piece work or a bonus system. In the latter case the personal interest of each worker in the smooth flow of material and the prevention of delays takes a tremendous load of detail supervision off the shoulders of the foremen, for which they must assume full responsibility under a time basis of wage payment. The shop scheduling system systematizing these details which otherwise would not receive adequate attention, thus preventing delays and assuring that the men are occupied during every hour for which they are paid. It must be remembered that responsibility for loafing by no means always rests with the men.

Some of the better known scheduling systems have been worked out in great detail, not only concerning the operations of the erection floor but following each piece of material through every department of the shop. No doubt these elaborate systems, involving a complete separation of the line and staff functions of shop management, can be justified by the results which they have produced. Nevertheless, the average shop officer cannot be blamed for a feeling of misgiving when suddenly asked to don a garment, ready-made and profusely trimmed with a type of "ginger-bread" entirely foreign to his taste. That the garment itself is of the right quality is demonstrated by the experience of the Milwaukee passenger car shop. How it shall be trimmed may well be left to the decision of those who must wear it.

Turbine Characteristics and Design of Turbo-Locomotives

THOSE who have been following recent tendencies in European locomotive development have observed an inclination toward the serious consideration of radical changes which would have been passed by as purely visionary but a few years ago. A number of these modifications have not only been propounded but are now being submitted to actual test. Among the most interesting of these is the attempt to utilize the steam turbine. For a number of years the steam turbine has been recognized as the leading prime mover for stationary power plants and more recently has to a large extent supplanted the reciprocating steam engine for marine propulsion. The engineers who have designed the turbine locomotives which already have been built or are under construction at the present time in Sweden, England, Switzerland and Italy appear to have a clear realization of the essential factors and difficulties of the problem.

On account of what is being done in Europe and in view of the fact that the efforts to secure greater economies may soon lead to similar attempts in this country, it will be of interest to note some of the characteristics and limitations of the steam turbine. In the first place the turbine is essentially a high speed machine and in order to show its greatest efficiency the speed at the blades must be maintained within rather narrow limits. The restrictions of space limitations may thus demand a rotative speed of from 3,000 to 5,000 r.p.m. This makes it necessary to introduce a reduction gear between the turbine spindle and the driving wheels of the locomotive. Fortunately decided improvements in high-speed, high-power reduction gears have been made during recent years and with the introduction of double helical gears and improved hobbing machines the gear problem does not appear to be sufficiently serious to prevent their use.

The turbine, unfortunately, has a low starting torque and the usual form is non-reversible. The problem of control consequently involves more than mere reduction gearing. This may require the introduction of some form of variable speed transmission. Reversing may be accomplished by means of the transmission or a separate reversing element may be mounted on the turbine spindle, a practice that is commonly employed in marine turbines.

A comparatively high vacuum is essential for the realization of the full economies to be obtained from the turbine. From 26 in. to 28 in. of vacuum is common in the best stationary and marine practice. Only about half of the work of the turbine is done during the expansion of the steam from boiler pressure to the exhaust pressure of the present reciprocating locomotive engine. The ordinary surface condenser occupies considerable space and requires a large amount of cooling surface as well as a liberal supply of cooling water. The design of a suitable condenser and the handling of the cooling water, including the recooling, which probably will have to be done by air currents, present several real difficulties in securing the necessary capacity. This involves the use of induced or forced draft controlled by a fan.

The turbine characteristics mentioned do not necessarily preclude its use on the locomotive, but they must be recognized and given full consideration in all attempts to work out a practical design of turbine locomotive.

COMMUNICATIONS

Air Openings Through Ashpans and Grates

Chicago, Ill.

To the Editor:

The editorial in the December *Railway Mechanical Engineer* under the caption of "Air Area Through Grates and Ashpans" is timely, as at this particular period many railroads are directing considerable thought toward the modernization of existing power with a view to increasing the overall efficiency.

In the development of an efficient locomotive it is a recognized fact that first consideration must be given to the locomotive boiler and as the firebox in which combustion takes place constitutes the primary factor in boiler efficiency, it follows that the design of the grate on which the fuel is burned is one of the vital points in furnace construction.

During Railroad Administration days the Fuel Conservation Section accumulated considerable data covering current practice on the various railroads throughout the United States insofar as ashpans, grates, front end draft appliances, etc., are concerned. It was found that practically all railroads recognize the necessity of ample air openings through or above the ashpan in order to obtain practically atmospheric pressure underneath the fuel bed under all conditions of locomotive operation and under varying rates of combustion. Undoubtedly, the necessity for and the advantages of ample ashpan air opening was conveyed to the different railroads through their traveling engineers as it was one of the subjects that was repeatedly stressed at several of the Traveling Engineers' conventions. In fact, one member made the assertion, which may be somewhat stretched in facts, that he never realized the advantage of a full air opening under the grates until on one trip he lost the ashpan and the boiler began to steam so freely that it blew up before the pops could relieve it.

While it was found that practically all railroads gave the matter of air openings through the ashpan consideration and endeavored as far as possible to establish a ratio of 14 per cent or more of air opening to total grate area, yet in most cases they stopped with the ashpan. The records show that insofar as air opening through grates is concerned, there was practically no uniformity of practice or design, the ratio of air opening to total grate area ranging from 20 to 50 per cent.

It is of course conceded that the design or type of grate must be governed by local conditions; that is, the character and characteristics of the fuel used. Regardless, however, of the type of grate, whether of the box, table or finger type, there should not be such great variation in the amount of air opening through the grate as was found to be the case.

As brought out in your editorial, fuel engineers long ago established the air requirements per pound of fuel in order to obtain perfect combustion. Repeated tests have demonstrated that in practically all instances in locomotive practice, there is a deficiency of oxygen immediately over the fuel bed under the higher rates of combustion. The grates offer the first obstruction toward the inflow of air. The varying thicknesses of the fuel bed and the accumulation of ash on top of the grates offer further restrictions.

The flow of air through any orifice, whether it be through the openings in the grates or the small openings in the fuel bed above the grates, is proportionate to the difference in pressure on either side of the opening. As it is necessary to introduce a given amount of air into a furnace per pound of fuel consumed, it follows that where there are restrictions in the openings, preventing a moderately free flow of air, we must increase the velocity of the air current in order to obtain the same volume in a given time as if no restrictions existed. In locomotive practice this increase in velocity is usually obtained at the expense of locomotive efficiency by increasing the front end vacuum through the reduction in nozzle area.

It is true that in ordinary locomotive operation in American practice where we use an exhaust nozzle of a fixed dimension, the front end draft is automatically increased with the increase in demand on the boiler for steam, yet observation indicates that in the majority of cases this increased demand for steam is anticipated by the firemen who prior to the expected demand increase the thickness of the fuel bed, thus offsetting in a measure the increased flow of air which would be obtained through increased draft.

Investigation of average manual firing practices indicates that the necessity for increasing the depth of the fuel bed is largely brought about through irregular spacing of the air openings through the grates. This irregular spacing has a tendency toward what is termed "pulling holes" in the fire, and the difficulty experienced by the firemen in filling the holes after they are formed leads to heavy firing.

From the above we can therefore draw the following conclusions—Grates should be designed with a view to obtaining an air opening equivalent to at least 50 per cent of the total grate area. The openings should be as nearly uniform in size as possible. A grate with many small openings, provided the sum total of the openings gives an equal area, is preferable to one with fewer but larger openings. The spacing should be uniform throughout. The type of grate should be governed by the fuel characteristics.

A grate designed as outlined will not only overcome in a large measure the "hole pulling" tendency incident to manual firing, but makes an ideal grate in connection with mechanical firing, being suitable for any kind of bituminous coal, i.e., lump, mine run or screenings, as well as lending itself readily to the use of sub-bituminous, semi-lignite or lignite. It also eliminates almost entirely the losses incident to firing up, that obtain with grates of larger and unequal air openings.

The subject is an interesting one and well worth the careful study of all concerned in locomotive design.

F. P. Roesch,
Western Manager, Standard Stoker Company.

New Books

Coal Manual, *F. R. Wadleigh.* 184 *pages,* 4½ *in. by* 6 *in. Published by the National Coal Mining News, Cincinnati, Ohio.*

Numerous books dealing with the subject of fuels and coal have been issued from time to time, but they usually have been written from the technical viewpoint of the engineer or chemist, or to meet the needs of the man in charge of power plants or locomotives. Few books have been available, however, which gave in a concise and accurate manner the general elementary information desired by a large number of men, such as purchasing agents, storekeepers and others who are more or less interested in some phase of the coal question other than that of actual mining. This manual has been prepared by a man who evidently knew his subject and in addition recognized the wants of the men for whom he wrote.

The subject matter has been well arranged and by the use of frequent subheads and an excellent index any information desired can be found readily—features which will increase the usefulness of the book for reference purposes.

Among the subjects covered are: kinds and commercial grades of coal; information in regard to the location of coal fields and the essential differences in the character of coal from various fields and seams; the preparation of coal; coke and gas manufacture; the use of coal in locomotives, stationary boilers and furnaces; storage and prevention of spontaneous combustion; specifications and their use; analyses and effects of various impurities, together with a brief bibliography on the subject of coal.

Report of the Bureau of Locomotive Inspection

Smaller Percentage of Defects—Fewer Accidents—Welding Firebox Crown Sheets Dangerous Practice

THE report of the chief inspector of locomotive boilers to the Interstate Commerce Commission for the fiscal year ending June 30, 1921, shows a decrease in the percentage of locomotive defects and a falling off in the number of accidents. The number of locomotives inspected moreover was larger than in any previous year since the bureau has been in operation. A summary of the report is given below.

Statistics

The tabulations have been arranged so as to permit comparison with previous years, and show the number of locomotives inspected, the number and percentage of those inspected found defective, and the number for which special notice for repairs was issued, withholding the locomotive from service because of having defects constituting violations of the law, together with the number of defects found; also the number of accidents caused by failure from any cause of the locomotive or tender and all parts and appurtenances thereof, together with the number of persons killed and injured as a result of such failure.

NUMBER OF LOCOMOTIVES INSPECTED, NUMBER FOUND DEFECTIVE, PERCENTAGE INSPECTED FOUND DEFECTIVE, NUMBER ORDERED OUT OF SERVICE, AND TOTAL DEFECTS FOUND BY YEARS

	1921	1920	1919	1918	1917
Number of locomotives inspected	60,812	49,471	59,772	41,611	47,542
Number found defective	30,207	25,529	34,557	22,196	25,909
Percentage found defective	50	52	58	53	54.5
Number ordered out of service	3,914	3,774	4,433	2,125	3,294
Total defects found	104,848	95,066	135,300	78,277	84,883

NUMBER OF ACCIDENTS, NUMBER KILLED AND NUMBER INJURED AS A RESULT OF FAILURE OF PARTS AND APPURTENANCES OF THE ENTIRE LOCOMOTIVE AND TENDER, BY YEARS

	1921	1920	1919	1918	1917
Number of accidents	735	843	565	641	616
Decrease from previous year (per cent)	12.8	*49.2	11.8	4.1	...
Number killed	64	66	57	46	62
Decrease from previous year (per cent)	3	*15.8	*23.9	25.8	...
Number injured	800	916	647	756	721
Decrease from previous year (per cent)	12.6	*41.6	14.4	4.8	...

*Increase.

NUMBER OF ACCIDENTS, NUMBER KILLED AND NUMBER INJURED AS A RESULT OF THE FAILURE OF SOME PART OR APPURTENANCE OF THE BOILER ONLY FOR THE FISCAL YEARS ENDED JUNE 30, 1912, 1915, 1920 AND 1921

	1921	1920	1915	1912
Number of accidents	342	439	424	856
Number killed	51	48	13	91
Number injured	379	503	467	1,005

DERAILMENTS DUE TO DEFECTS IN OR FAILURE OF SOME PART OF THE LOCOMOTIVE OR TENDER, AND THE NUMBER OF PERSONS KILLED AND INJURED AS A RESULT OF SUCH DERAILMENTS FOR THE FISCAL YEARS ENDED JUNE 30, 1917-1921, INCLUSIVE

	1921	1920	1919	1918	1917
Number of derailments*	8	7	7	2	4
Number killed	...	7	6	...	1
Number injured	30	18	7	2	21

*Only derailments reported by carriers as being caused by defect in or failure of parts of the locomotive or tender were investigated or counted in this tabulation.

A summary of accidents and casualties occurring during the fiscal year ended June 30, 1921, as compared with the year ended June 30, 1920, covering the entire locomotive and tender and their appurtenances, shows a reduction of 12.8 per cent in the number of accidents, 3 per cent in the number killed, and 12.6 per cent in the number injured.

During the first six months of the fiscal year 1921 accidents and casualties occurred at an alarming rate and exceeded those of any like period during the five preceding years. However, during the last six months a marked reduction is recorded. The number of accidents and casualties during the year was considerably in excess of those occurring during the year 1919, a large number of accidents resulting in serious injury being caused by the failure of what are frequently termed unimportant parts. For instance, during the year 85 accidents were caused by the

ACCIDENTS AND CASUALTIES RESULTING FROM FAILURES OF LOCOMOTIVES AND TENDERS AND THEIR APPURTENANCES

Part or appurtenance which caused accident	Year ended June 30 1921 Accidents	1921 Killed	1921 Injured	1920 Accidents	1920 Killed	1920 Injured	1919 Accidents	1919 Killed	1919 Injured
Air reservoirs	1	..	1	2	1	2	2	..	2
Aprons	16	..	16	8	..	8	5	..	5
Arch tubes	5	..	5	9	1	15	7	2	9
Ash-pan blowers	5	..	5	6	1	5	11	1	10
Axles	5	..	6	5	..	5	2	..	2
Blow-off cocks	14	..	14	15	..	15	4	..	4
Boiler checks	7	1	7	5	..	6	4	..	4
Boiler explosions	..	..	..	..	..	..	..	..	..
A. Shell explosions	..	..	..	..	..	..	..	..	..
B. Crown sheet; low water; no contributory causes found	20	19	26	24	22	35	31	26	46
C. Crown sheet; low water; contributory causes or defects found	33	24	52	35	19	46	34	13	63
D. Firebox; defective staybolts, crown stays, or sheets	1	2	..	2	..	2	2	..	3
E. Firebox; water foaming	..	..	..	..	..	..	..	..	..
Brakes and brake rigging	6	..	6	3	..	3	8	3	10
Couplers	11	1	13	8	..	8	12	..	14
Crank pins, collars, etc	6	3	8	4	..	4	5	..	6
Crossheads and guides	4	1	4	5	2	3	5	..	5
Cylinder cocks and rigging	4	..	4	..	..	..	2	..	2
Cylinder heads and steam chests	6	..	6	9	..	9	5	..	7
Dome caps	..	..	..	..	..	..	..	..	..
Draft appliances	8	..	9	1	..	1	2	..	4
Draw gear	8	1	8	11	..	9	7	1	6
Fire doors, levers, etc	8	..	8	1	..	11	7	..	7
Flues	32	1	35	45	..	52	33	1	39
Flue pockets	1	1	..	..	..	..	2	..	2
Footboards	8	3	5	23	..	23	7	..	7
Gage cocks	..	..	..	9	1	9	4	..	5
Grease cups	7	..	7	2	..	2	..	..	..
Grate shakers	85	..	85	10	..	10	3	..	3
Handholds	19	..	20	108	..	109	37	1	36
Headlights and brackets	8	2	6	15	1	14	16	1	15
Injectors and connections (not including injector steam pipes)	15	2	13	3	..	27	21	..	22
Injector steam pipes	15	..	17	23	1	29	14	..	20
Lubricators and connections	12	..	12	14	..	15	11	..	13
Lubricator glasses	3	..	3	17	..	17	9	..	9
Patch bolts	..	..	..	..	..	..	..	..	..
Pistons and piston rods	3	..	3	3	1	3	2	..	2
Plugs, arch tube and washout	15	..	18	26	..	40	30	1	34
Plugs in fire box sheets	2	..	2	1	..	2	2	1	1
Reversing gear	65	..	65	59	..	59	31	..	31
Rivets	4	..	5	..	..	..	2	..	2
Rods, main and side	18	..	21	16	2	20	14	..	15
Safety valves	..	..	..	..	..	..	1	..	1
Sanders	..	..	..	1	..	1	..	..	..
Side bearings	..	..	..	..	..	..	1	..	1
Springs and spring rigging	3	..	3	9	2	18	5	2	4
Squirt hose	82	..	82	82	..	82	54	..	54
Staybolts	..	..	..	2	2	1	2	..	2
Steam piping and blowers	9	..	9	13	1	19	8	..	11
Steam valves	11	..	12	17	..	17	9	..	10
Studs	7	..	7	9	..	11	7	..	9
Superheater tubes	1	..	2	4	..	6	1	..	1
Throttle glands	..	..	..	3	..	4	..	..	..
Throttle leaking	3	..	3	1	1	..	1	..	1
Throttle rigging	1	..	1	6	..	6	4	1	7
Trucks, leading, trailing, or tender	6	..	8	1	3	1	2	1	2
Valve gear, eccentrics and rods	10	..	10	6	..	6	9	..	9
Water bars	..	..	..	..	..	..	..	..	..
Water glasses	25	..	25	32	..	32	26	..	26
Water-glass fittings	2	..	2	4	..	4	4	..	4
Wheels	4	1	4	2	1	4	3	..	5
Miscellaneous	91	2	117	87	2	86	35	2	35
Total	735	64	800	843	66	916	565	57	647

failure of some part of the grate-shaking apparatus, 82 by squirt hose, and 65 by some part of the reversing gear, all of which could have been avoided by reasonable care.

There were no authentic records from which comparisons could be made of accidents prior to the enactment of the boiler inspection law. A comparison, however, of the fiscal year ended June 30, 1912, the first year of the law, with the fiscal year 1915, the year in which the law was amended, and 1921, the present year, is of importance, and shows the far-reaching effect of proper inspection and repair, as required by the law and the rules established thereunder.

Comparing 1912, covering parts and appurtenances of the boiler only, with the year 1915, the fourth year of the law, there is shown to be a reduction of 50 per cent in the number of accidents, 85.7 per cent in the number killed, and 53.5 per cent in the number injured.

Comparing 1912, with the year 1921, covering parts and appurtenances of the boiler only, there is shown to be a reduction of 60 per cent in the number of accidents, 44 per cent in the number killed and 62 per cent in the number injured.

Comparing 1915, the fourth year of the existence of the law, with the year 1921, there is shown a decrease of 19 per cent in the number of accidents, an increase of 292 per cent in the number killed, and a decrease of 17 per cent in the number injured, due to the failure of some part or appurtenance of the boiler only. Barrel explosions have been entirely eliminated, and while the so-called crown-sheet failures have materially decreased, the great increase in fatalities indicates that the severity of these failures has increased tremendously.

Welded Firebox Sheets

During the year there were a number of accidents investigated in which firebox seams formed by the autogenous welding process were involved, where, through the failure of these seams, it is believed the result of the accident was much more serious than would otherwise have been. Auto-

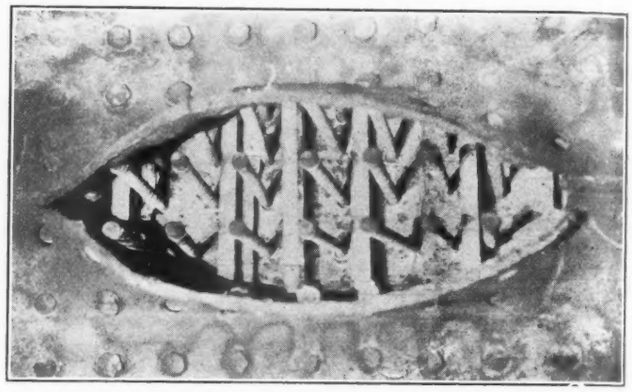
Low Water Caused Crown Sheet Failure and Boiler Explosion

genous welding can be used on many parts of the locomotive and tender and on parts of the stayed surfaces of the boiler with safety and economy, but inasmuch as the bureau's accident investigations show that approximately 80 per cent of the autogenously welded seams fail, where they are involved in the accidents, it is believed that such methods should be avoided in firebox crown-sheet seams where overheating and failure are liable to occur, or on any part of the boiler where the strain to which the structure is subjected is not carried by other construction which fully meets with the requirements of the rules, at least until some means has been developed through which the quality and tenacity of the weld may be established in advance of its failure. This should apply on all parts of the locomotive and tender where, through failure, an accident and an injury might result.

Boiler Explosions

The next portion of the report is devoted to a discussion of the theory of boiler explosions and to what takes place in such occurrences.

The force of a boiler explosion is in proportion to the size and suddenness of the initial rupture and the temperature and volume of the water in the boiler at the time of the rupture. The average modern boiler has a capacity of ap-



Crown Sheet Failure Caused by Low Water: Seam Had Been Autogenously Welded

proximately 500 cu. ft. of water below the crown-sheet and has a steam space of about 150 cu. ft. If such a boiler with 200 lb. pressure ruptures from any cause, so as to suddenly reduce the pressure to that of the atmosphere, the released energy will amount to approximately 700,000,000 ft.-lb. and if the explosion took place in two seconds approximately 690,000 h.p. would be developed.

This gives some idea of the force which accompanies many boiler failures, with their serious and fatal results, and supplies the reason for the violence which in many cases is sufficient to hurl the entire boiler several hundred feet.

Explosions result because some part of the vessel is too weak to withstand the pressure to which it is subjected. This weakness may be caused by: 1. Abnormal steam pressure. 2. Weakness in design or construction. 3. Improper workmanship. 4. Corrosion or wasting away of material. 5. Broken or defective stays. 6. Overheated firebox sheets.

A remedy for the first three causes is provided for in the law and rules by requiring that the working pressure be fixed, after consideration of each individual boiler by competent authorities, and by fixing a substantial factor of safety to provide against defects of material and construction.

To protect against failure due to corrosion or other defects caused by wear and usage, the law requires that regular inspections, both interior and exterior, be made and that all boilers be subjected to a hydrostatic test at regular intervals and a sworn report filed showing the conditions found and repairs made.

Failure of crown or firebox sheets, due to overheating, may be the result of scale or grease on the firebox sheets or from low water. The firebox sheets and tubes are in contact with the fire, and would become heated to that temperature if it were not for the presence of water in the boiler. As previously explained, the temperature of the water depends on the boiler pressure, but rarely reaches more than 400 deg. F; therefore while the plates are in contact with the water on one side they can not greatly exceed this temperature, although the temperature in the firebox may exceed 2,500 deg., which is about the fusing point of firebox steel.

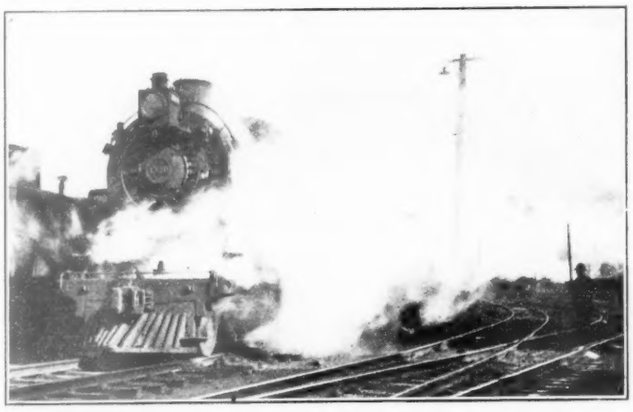
The heat in the firebox is conducted through the plate to the water in the boiler, where it is absorbed, the sheet thus

being prevented from heating to the temperature of the fire and burning gases. If, however, the transmission of the heat to the water is obstructed by scale or grease, or if the water fails to absorb the heat, due to being foamy, the plates will retain the heat, and may become red hot; or if the sheets are unprotected by water from any cause they become overheated. Metal loses strength when heated, and if heated to a high temperature has comparatively little strength to resist the pressure within the boiler, when as a result the sheets are forced off the stays and failure occurs. It is a well-recognized fact that scale or grease may be the direct cause of an explosion. Scale may indirectly cause an explosion by restricting or closing the openings in the water-indicating appliances, thereby causing a false level of water to be registered, deceiving the enginemen.

Water Gages and Glasses

One of the most perplexing problems which has presented itself while operating the modern locomotive is that of securing a correct indication of the height of water over the crown-sheet under all conditions of service.

In the last annual report was included the results of tests made to determine the action of water in the boiler on the water-indicating appliances with respect to their correct registration. These tests established that gage cocks screwed directly in the boiler do not correctly indicate the general



Leaking Badly But Reported Ready for Service: Cylinder Cocks Closed

water level while steam is rapidly escaping from the boiler, and in order to secure a proper appliance it was recommended that a water column to which three gage cocks and one water glass were attached be applied.

As far as the bureau has been able to determine, practically all new locomotives constructed since that report was rendered have had water columns applied. On old locomotives the application has not progressed rapidly, probably due to the difficulty in obtaining necessary appropriations. The necessity for such appliances, however, is practically unquestioned, and some roads are proceeding with the application in a very satisfactory way. It is hoped that in the near future this important appliance will be applied on all locomotives, so that enginemen may have accurate knowledge of the general water level in the boiler under all conditions of service.

Flue Removals

During the year 209 applications were filed for extension of time for the removal of flues, as provided in rule 10. Investigation showed that in 25 of these cases the condition of the locomotives was such that no extension could properly be granted; 22 were in such condition that the full extension requested could not be granted, but an extension for a shorter period within the limits of safety was allowed; 25 extensions were granted after defects disclosed by investigation had been repaired; 38 applications were withdrawn for various reasons; the remaining 99 were granted for the period requested.

Headlights

On July 1, 1920, the rules became effective requiring each locomotive used in road service between sunset and sunrise to be equipped with a headlight which will enable the enginemen to see in a clear atmosphere a dark object as large as a man 800 ft. ahead of the locomotive and that yard locomotives have one light on the front and one on the rear that will enable the enginemen to see 300 ft. ahead of the locomotive. These requirements have been given close attention and have been fully complied with. The lighting equipment with which locomotives are now equipped seems to be meeting with the universal approval of officials and employees required to operate and maintain them.

The fact that not a single formal appeal has been taken from the decision of any inspector during the fiscal year demonstrates that wisdom and good judgment have been exercised by the inspectors in the performance of their duties.

Recommendations

In closing the report the following recommendations were made:

That the act of February 17, 1911, be amended so as to provide for additional inspectors to be appointed by the commission as the needs of the service develop, and that adequate salaries may be paid that will obtain and retain in the service a full corps of well-trained, efficient inspectors, and that the amounts directly appropriated be increased to meet the requirements.

That all locomotives not using oil for fuel have a mechanically operated fire door so constructed that it may be operated by pressure of the foot on a pedal or other suitable device located on the floor of the cab or tender at a proper distance from the fire door, so that it may be conveniently operated by the person firing the locomotive.

The old swing-type door, which is largely used at present, is almost invariably blown open in case of firebox accidents. The automatic fire door would remain closed if closed when the accidents occur. If open, it would automatically close the moment the operator's foot was removed from the operating device, thus preventing the direct discharge of the scalding water and fire into the cab of the locomotive with such serious results.

The automatic fire door is not a new and untried device, as there are thousands of them in service, and they are required by law in some states. The automatic fire door is also of great value in prevention of serious cracks and leaks in firebox sheets.

That all locomotives be provided with a bell so arranged and maintained that it may be operated from the engineer's cab by hand and by power.

That cabs of all locomotives not equipped with front door or windows of such size as to permit of easy exit have a suitable stirrup or other step and a horizontal handhold on each side approximately the full length of the cab, which will enable the enginemen to go from the cab to the running board in front of it.

That all locomotives where there is a difference between the readings of the gage cocks and water glass of two or more inches under any condition of service be equipped with a suitable water column, to which shall be attached three gage cocks and one water glass, and one water glass on the left side or back head of the boiler. Investigations have clearly established that gage cocks were screwed directly into the boiler do not correctly register the proper water level over the crown sheet. It is very important that at least two appliances attached separately be employed for this purpose so as to form a double check and so as to have one appliance in case of failure of the other while on the road and away from points where repairs can be made.

Mikado Type for the Central Railroad of New Jersey, Built by the American Locomotive Company.

Rolling Stock Orders Unusually Small in 1921

Decreased Traffic and Idle Equipment Result in Few Domestic Orders; Foreign Purchases Also Small

THE year 1921 was characterized by a falling off in general traffic and consequently by an accumulating number of idle and bad-order locomotives and cars. As a result the orders for all kinds of new equipment were abnormally small.

Locomotives

The orders placed for locomotives for domestic service in the United States in 1921 totaled 239, as compared with 1,998 in 1920. In 1919, the second year of federal control, the locomotives ordered for domestic service in the United States totaled 214; the 1921 figure, poor as it was, luckily succeeded in bettering slightly that ignominious record.

Orders placed by railroads in Canada with Canadian builders totaled 35, as compared with 189 in 1920 and 58 in 1919.

Export locomotive orders for 1921 aggregated 546, inclusive of orders placed by lines in Mexico. This compared with 718 in 1920 and 898 in 1919. The Mexican lines in 1921 placed the largest order for any system in North America, the National Railways of Mexico having ordered a total of 142 locomotives.

Production in 1921 totaled 1,121 locomotives for domestic service and 587 for export. The 1,121 although it was several times the number of new locomotives ordered during 1921, was the lowest total the American locomotive manufacturers have experienced for many years. It compared with 1,857 (exclusive of Canada) in 1920. One has to go back to 1897 to find a lower figure than the 1921 performance. A fair number of locomotives were sent to the builders for heavy repairs or rebuilding and this helped the situation to some extent.

During a large part of the year reports showed considerable numbers of serviceable locomotives stored and a high percentage of unserviceable locomotives. On December 1, according to the A. R. A. Car Service Division reports, there were 5,308 serviceable locomotives stored and 12,170, or 18.8 per cent, held for repairs requiring over 24 hours. At various times during the year the "bad order" locomotives approached 20 per cent. It is an interesting fact that this is a matter which received but small attention during the year. The contrast as between the publicity given the bad order car figure and that given the unserviceable locomotive per cent is especially striking. The reason for the failure to pay attention to the locomotive condition situation is quite evident. In a period when expenses had to be cut to the bone, one would hardly have expected the operating officer to overexert himself about his per cent of unserviceable locomotives while he had a sizable number of serviceable locomotives in white lead. It was hardly to be expected either that such a period woud be productive of large orders for new locomotives. However, even at that, the 1921 total

TABLE I—ORDERS FOR LOCOMOTIVES SINCE 1901

Domestic orders only

Year	Locomotives	Year	Locomotives
1901	4,340	1908	1,182
1902	4,665	1909	3,350
1903	3,283	1910	3,787
1904	2,538	1911	2,850
1905	6,265	1912	4,515
1906	5,642	1913	3,467
1907	3,482	1914	1,265

Domestic and Foreign

Year	Domestic	Foreign	Total
1915	1,612	850	2,462
1916	2,910	2,983	5,893
1917	2,704	3,438	6,142

Year	Class I railroads	Other American railroads	Domestic industrials	Total domestic	Canadian	For export	Grand total
1918	2,548	7	38	2,593	209	2,086	4,888
1919	....	....	....	214	58	898	1,170
1920	1,668	103	227	1,998	189	718	2,905
1921	190	20	29	239	35	546	830

TABLE II—LOCOMOTIVES BUILT IN 1921

	United States	Canada	Total
Domestic	1,121	64	1,185
Foreign	587	51	638
Total	1,708	115	1,823

Comparison with Previous Years

Year	Domestic	Foreign	Total	Year	Domestic	Foreign	Total
1896	866	309	1,175	1908*	1,886	456	2,342
1897	865	386	1,251	1909*	2,596	291	2,887
1898	1,321	554	1,875	1910*	4,441	314	4,755
1899	1,951	514	2,475	1911*	3,143	387	3,530
1900	2,648	505	3,153	1912†	4,403	512	4,915
1901	....	...	3,384	1913†	4,561	771	5,332
1902	....	...	4,070	1914†	1,962	273	2,235
1903	....	...	5,152	1915†	1,250	835	2,085
1904	....	...	3,441	1916†	2,708	1,367	4,075
1905*	4,896	595	5,491	1917†	2,585	2,861	5,446
1906*	6,232	720	6,952	1918†	3,668	2,807	6,475
1907*	6,564	798	7,362	1919†	2,162	1,110	3,272
				1920†	2,022	1,650	3,672

*Includes Canadian output.
†Includes Canadian output and equipment built in railroad shops.

is rather disappointing. One can find consolation at least in the fact that this condition cannot last. The American railroads have got to make up their deferred motive power requirements some time.

With further reference to the domestic orders, the only systems which placed contracts of any size—and even their orders were not large—were the Atchison, Topeka & Santa Fe, the Southern Pacific, the Seaboard Air Line, the Central of New Jersey and the Rock Island. All the additional orders were of small size, being only of from one to eight locomotives. In the small total there is noticeable a comparatively large proportion of Santa Fe and Mountain type locomotives, which is what one would naturally expect. Brick arches and superheaters have now been so generally adopted that it is a rare thing for a new locomotive to be built without them. Stokers and power reverse gears also are usually applied to all heavier power and the past year has evidenced a growing tendency to the more extended use of feedwater heaters and boosters.

The number of locomotives ordered in 1921 for export was small, even if it was double the domestic orders. The largest order, as already noted, was from Mexico—that is, if it is proper to include in the foreign orders, locomotives to be delivered to a road which subscribes to the A. R. A. Code of Interchange Rules, as do the National Railways of Mexico. The other countries which furnish sizable business were Argentina, Chile, China, Brazil and Japan. Much of this business was obtained in spite of the keenest competition, considerable of it from German builders whose quotations were at times below those of the successful American bidder. In such cases the American reputation for prompt deliveries was frequently a deciding factor.

The orders from Argentina were principally from the State Railways. The Japanese business is of interest because Japan has a considerable locomotive production of its own. The Chilean State Railways, which ordered 30 steam locomotives, merit attention because they placed the largest electric locomotive order of the year—35 locomotives for the new electrification out of Santiago.

In looking over the foreign specifications it is evident that the railroads in other countries are appreciating the economic advantages to be obtained from the use of considerably heavier power than that which they have hitherto purchased, although naturally the locomotives are lighter than those used on American roads. It is interesting to note that whereas only one Mallet locomotive was ordered in 1921 by an American railroad, a number were ordered for use in China, these being the heaviest locomotives built for use on any road outside of the United States.

An interesting point in connection with the export trade is the paucity of orders from European countries this year and the absence of Cuba—due to ill-fortunes of the sugar industry—from the list of purchasers. In the foreign field, as well as in the domestic field, the controlling factor was the difficulty, at times insurmountable, of obtaining either the necessary capital or credit. In a number of instances the locomotive builders were obliged to arrange for the necessary financing.

Freight Cars

Freight cars ordered for domestic service in the United States during 1921 totaled 23,346, the lowest for any year on record except 1919. The orders compared with 84,207 in 1920. During the second year of federal control, 1919, practically the only orders placed in North America were those for private car lines and industrials; the total including Canada was 25,899 cars; the 1921 figure succeeded in lowering that unenviable record.

Export orders in 1921 totaled 4,982; this is half the total for 1920, in excess of the figure for 1919, but less than one-tenth the averages for the years 1917 and 1918.

The number of freight cars ordered in 1920 was not large. It did, however, permit the car builders to start 1921 with a fair amount of uncompleted business on their books. The 1921 orders were so few that the year was primarily spent in cleaning up the hold-over 1920 business. The result was minimum production—the totals for the year reaching 40,292 cars built for domestic service and 6,412 for export. For all the fact that the production for freight cars for the past several years has been at a low average, the 1921 total was less than that for any other year for an indefinite period. Fortunately, there was a reasonable amount of work in the form of freight car repairs to alleviate the situation; but it can hardly be said that repair business went very far in that direction.

TABLE III—ORDERS FOR FREIGHT CARS SINCE 1901

Domestic orders

Year	Freight cars	Year	Freight cars
1901	193,439	1908	62,669
1902	195,248	1909	189,360
1903	108,936	1910	141,024
1904	136,561	1911	133,117
1905	341,315	1912	234,758
1906	310,315	1913	146,732
1907	151,711	1914	80,264

Domestic and foreign

Year	Domestic	Foreign	Total
1915	109,792	18,222	128,014
1916	170,054	35,314	205,368
1917	79,367	53,191	132,558

Year	Class I railroads	Other American railroads	Private car lines and industrials	Total domestic	Canadian	For export	Grand total
1918	101,063	904	12,146	114,113	9,657	53,547	177,317
1919	.....	.....	.....	22,062	3,837	3,994	29,893
1920	51,250	1,044	31,913	84,207	12,406	9,056	105,669
1921	21,003	923	1,420	23,346	30	4,982	28,358

The reason for the small quantity of new orders for domestic service in 1921 is due to several factors—the low net railway operating income; the decreased net ton-miles; the large proportion of idle cars; and the percentage of bad order cars. These factors were more or less interrelated. In a poor year of rather more than ordinary poorness, the existence of any one of them could have been blamed for acting as a drag on freight car business. The combination of them succeeded in making 1921 a record-breaker of the wrong sort.

TABLE IV—FREIGHT CARS BUILT IN 1921

	United States	Canada	Total
Domestic	40,292	8,404	48,696
Foreign	6,412	745	7,157
	46,704	9,149	55,853

Comparison with Previous Years

Year	Freight: Domestic	Freight: Foreign	Freight: Total
1899	117,982	1,904	119,886
1900	113,070	2,561	115,631
1901	132,591	4,359	136,950
1902	161,747	2,800	162,599
1903	153,195	1,613	152,801
1904	60,955	1,995	60,806
1905*	162,701	5,305	165,155
1906*	236,451	7,219	240,503
1907*	280,216	9,429	284,188
1908*	75,344	1,211	76,555
1909*	91,077	2,493	93,570
1910*	176,374	4,571	180,945
1911*	68,961	3,200	72,161
1912†	148,357	4,072	152,429

*Includes Canadian output.
†Includes Canadian output and equipment built in company shops.

	United States: Domestic	United States: Foreign	United States: Total	Canadian: Domestic	Canadian: Foreign	Canadian: Total	Grand Total
1913	176,049	9,618	185,667	22,017	.....	22,017	207,684
1914	97,626	462	98,088	6,453	.....	6,453	104,451
1915	58,226	11,916	70,142	1,758	2,212	3,970	74,112
1916	111,516	17,905	129,421	.....	.....	5,580	135,001
1917	115,705	23,938	139,643	3,658	8,100	11,758	151,401
1918	67,053	40,981	108,044	14,704	1,960	16,664	124,708
1919	94,981	61,783	156,764	6,391	30	6,421	163,185
1920	60,955	14,480	75,435	.....	.....	.....	.....

The net freight car surplus varied during the year between 68,984 on October 31 to 507,274 on April 8. On December

15 it was 371,044. The year 1921 is the only year on record in which idle cars climbed over the 500,000 mark. The years during which at any time the surplus has gone over even 300,000 are very few. They include 1908, when the highest figure was 413,338; possibly 1914, during a portion of which the total got so large that the compilation of figures was abandoned; in 1915, when 327,084 was reported; and in 1919, when the peak was reached of 448,864.

Large car surpluses and declining totals of net ton-miles are not unusual, such a large percentage of bad order cars, however, was a feature more or less singular to 1921. The bad order cars on January 1 totaled 191,234, or 8.5 per cent. They increased during the early part of the year, until on August 15 they totaled 382,440, or 16.6 per cent. On December 1 this had been reduced to 320,292, or 14 per cent.

Fortunately, the gradually declining percentage of bad order cars indicates an improvement in the situation. In fact, all four of the factors which we blamed for the disappointing 1921 business are, looking at it in the larger way, showing improvement.

Sizable orders were reported in 1921 by but few roads. The Atchison, Topeka & Santa Fe ordered 1,300 gondola and 2,500 refrigerator cars. The Baltimore & Ohio contracted for 3,000 hopper and box car bodies to be used for replacements. The Chicago, Milwaukee & St. Paul placed orders for 2,500 gondola cars. The Lackawanna reported 1,500 hopper and 500 box cars. The Illinois Central secured 1,000 refrigerator cars. Other large orders are reported for the Louisville & Nashville, 2,800 cars, and the Minneapolis, St. Paul & Saulte Ste. Marie, 1,300. The absence of the New York Central and Pennsylvania from the lists is noticeable; these roads, however, received large allocations of U. S. R. A. standard equipment, and the former also placed large orders in 1920.

Another interesting but disappointing factor was the small amount of orders for private car lines and industrials. Canadian orders were likewise conspicuous by their absence.

The export orders for the year were not large. Such business, however, has apparently been brought to a more stable basis than was the case when the larger part of the business was placed by European countries which had car-building plants of their own but which were used for other purposes during the war. The Argentine State Railways purchased 2,000 cars; the Chilean State Railways, 320; China also purchased a fairly large number. The order given a Canadian company for 500 tank cars for the Russian Soviet Government merits more than passing attention. The Chinese orders and those from South America—in the latter case from the state owned railways—prove the contentions made in the recent past that it was among such purchasers that our foreign business was most likely to be found.

Passenger Train Equipment

The passenger cars ordered for service in the United States totaled in 1921 but 246. This is the smallest number in any year on record for at least 20 years, with the exception of the year 1918, when every energy was bent towards war-time activities. Foreign orders in 1921 totaled 155. The figure compares with 38 cars ordered for export in 1920 and 143 in 1919.

The passenger car production, as distinguished from orders, was 1,275, as compared with 1,272 in 1920. Cars built for export totaled only 39.

Although the railroads need passenger cars, they have purchased but few in the last five years in spite of the greatly increased business developed during these years.

The tendency for many years has been towards steel passenger train equipment. The Interstate Commerce Commission in its latest annual report repeats its previous recommendation that the use of steel cars in passenger service be required. The progress in the direction of replacing wooden cars in the past few years has been disappointing. The lack of such progress will only increase the difficulties of the carriers, should the commission's recommendation ever be adopted and put in the form of an act of Congress.

Only two roads placed fair-sized orders for passenger train equipment during 1921. The New York, Ontario & Western ordered 32 cars and the Reading, 50. The latter is expected shortly to order additional cars. The Missouri, Kansas & Texas ordered 54 cars, but 50 of these were express refrigerator cars and are included in the passenger car list only because they will presumably be operated in passenger trains.

South America and China were the largest foreign buyers. The Argentine Government ordered 53, the Chilean State Railways ordered ten, and railways in Colombia, 28. The Tientsin-Pukow of China gave us an order for 45. It is noteworthy that in the case of the Chilean and Tientsin-Pukow cars, all-steel construction was specified.

TABLE V—ORDERS FOR PASSENGER CARS SINCE 1901

Domestic orders only

	Passenger cars		Passenger cars
1901	2,879	1909	4,514
1902	3,459	1910	3,881
1903	2,310	1911	2,623
1904	2,213	1912	3,642
1905	3,289	1913	3,179
1906	3,402	1914	2,002
1907	1,791	1915	3,101
1908	1,319		

Domestic and Foreign

Year	Domestic	Foreign	Total
1916	2,544	109	2,653
1917	1,124	43	1,167

Year	Class I railroads	Other domestic	Total domestic	Canadian	For export	Grand total
1918	5	104	109	22	26	157
1919	....	....	292	347	143	782
1920	1,115	666	1,781	275	38	2,094
1921	207	39	246	91	155	492

TABLE VI—PASSENGER CARS BUILT IN 1921

	United States	Canada	Total
Domestic	1,275	361	1,636
Foreign	39	...	39
	1,314	361	1,675

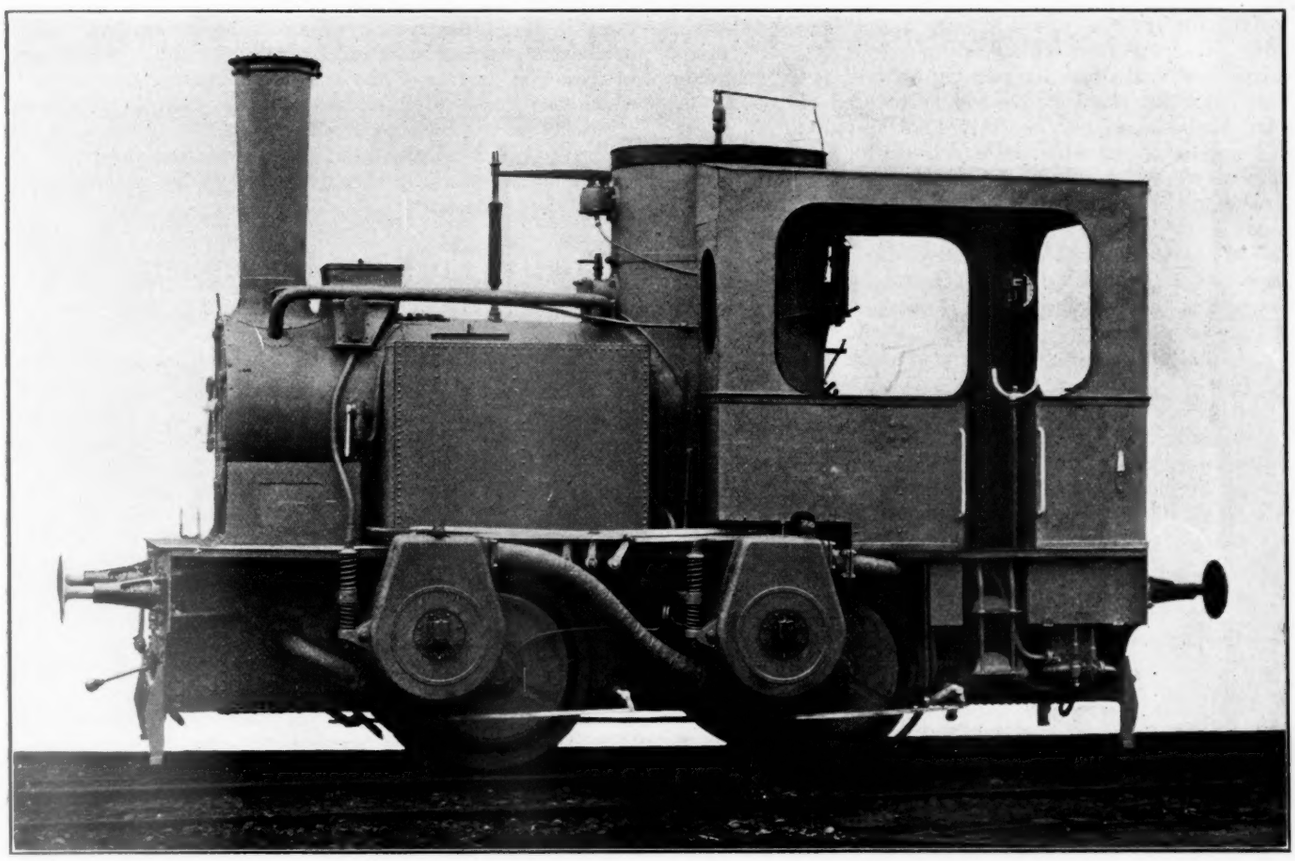
Comparison with Previous Years

Year	Passenger: Domestic	Passenger: Foreign	Passenger: Total
1899	1,201	104	1,305
1900	1,515	121	1,636
1901	1,949	106	2,055
1902	From 1902 to 1907 passenger		1,948
1903	car figures in these two		2,007
1904	columns included in corre-		2,144
1905*	sponding frt. car columns.		2,551
1906*	....	...	3,167
1907*	....	...	5,457
1908*	1,645	71	1,716
1909*	2,698	151	2,849
1910*	4,136	276	4,412
1911*	3,938	308	4,246
1912†	2,822	238	3,060

Year	United States: Domestic	United States: Foreign	United States: Total	Canadian: Domestic	Canadian: Foreign	Canadian: Total	Grand Total
1913	2,559	220	2,779	517	....	517	3,296
1914	3,310	56	3,366	325	....	325	3,691
1915	1,852	14	1,866	83	....	83	1,949
1916	1,732	70	1,802	37	....	37	1,839
1917	1,924	31	1,955	45	....	45	2,000
1918	1,480	92	1,572	1	....	1	1,503
1919	306	85	391	160	....	160	551
1920	1,272	168	1,440	....	....	....	....

*Includes Canadian output.
†Includes Canadian output and equipment built in company shops.

OF THE TOTAL of 1,739 passenger cars owned by the Pacific system of the Southern Pacific, 890 are all-steel, 812 are wood and 37 are of steel underframe construction. The first steel coach, built as an experiment, was completed in the Sacramento shops of the company in 1906, and no wooden passenger cars have been built by the company since 1910.



Italian Locomotive Equipped with Four Turbines

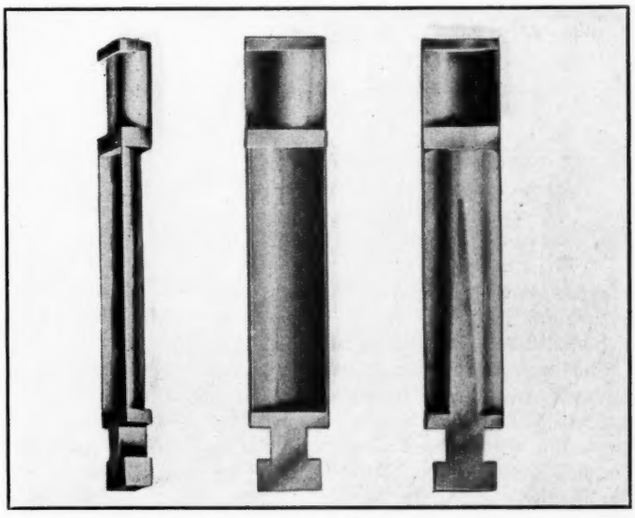
The First Steam Turbine Locomotive

THE first steam turbine locomotive actually constructed was designed in 1907 by Professor Belluzzo of the Ecole Polytechnique, Milan, Italy, and given its initial trial run in 1908 at the works of the Societe Anonyme Officine Meccaniche, Milan.

An old four-wheel standard gage switching locomotive was employed for the purposes of the test, the cylinders and other parts of the reciprocating engine being removed and turbines and necessary control mechanism substituted. This engine had 47¼-in. driving wheels, a wheel base of 6 ft. 6¾ in., a heating surface of 646 sq. ft. and carried a boiler pressure of 145 lb. per sq. in. The weight after conversion was 57,300 lb.

Four turbines were employed, one turbine being geared to each end of the two axles. Steam was admitted from the boiler to the forward turbine on the right hand side, and after passing through this turbine it was further expanded through the rear turbine on the right hand side, then passed to the left hand side of the locomotive, where it expanded through the turbines geared to the rear and front wheels and finally exhausted to the front end and stack. The turbines were spring supported as shown in the illustration and in addition flexible piping was used to connect the turbines. The maximum rotative speed of the turbines was 2,400 r.p.m., which with a gear ratio of 12 to 1 corresponds to a locomotive speed of 28 miles per hour.

As will be noted from the drawing of one of the turbines, it consisted of a steel disc rotor having three sets of blades. Between the rotor blades were two sets of stationary blades and on the inlet side a series of short guide blades which acted as nozzles for directing the steam to the first set of rotating blades. In order that the locomotive might be run in either direction, the blades had the lower portion curved in one direction and the outer portion curved in the opposite



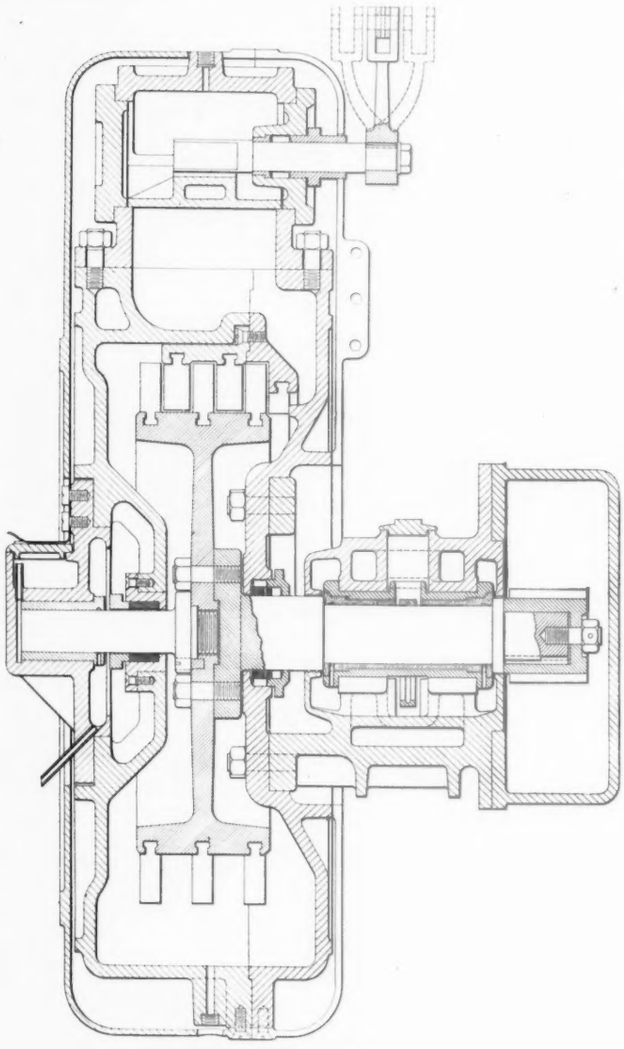
Special Blades for Running Both Forward and Backward

direction, the steam expansion being through the lower portion when the locomotive was going ahead and through the outer portion when it was backing up. An illustration of

one of the blades shows the novel arrangement employed.

Each turbine was provided with a steam chest in which three cylindrical distributing valves were fitted. One of the valves furnished steam for running forward at the maximum speed, one for running forward at reduced speed and the third for backing up. The valves on the four turbines were so connected together by rods and levers that each set of four were controlled in unison by a main lever in the cab convenient to the engineman.

All developmental work was necessarily suspended during the war. Although this locomotive was fitted up a number of years ago and tests were not completed or the locomotive placed in regular service, the work which was done is



Sectional View of Turbine

of especial interest at this time in view of the fact that experimental turbine driven locomotives are now in operation in Switzerland and also in Sweden.

This early Italian locomotive has recently been dismantled. However, sufficient information was obtained to induce the builders to bring out a new design for a 1,500 hp. locomotive using superheated steam and an air cooled condenser. The new locomotive is of the Pacific type and it is estimated that the weight will be about 70 tons. Experiments would indicate that the condenser can maintain a vacuum of 28 in. The turbines are rigidly attached to the frames and drive a transverse shaft through double reduction gears. This shaft is provided with cranks from which connections are made to the driving wheels by the usual main and side rods.

The success and economy of the turbine has led to its extensive use during recent years in the stationary and marine fields, this progress being made possible by the improvements in reduction gearing. The steadily increasing cost of fuel, which was already high in many countries, recently has caused a number of engineers to attack the difficult problem of the application of a turbine drive to the steam locomotive. The results of the efforts in this direction will be watched with the greatest interest.

Zoelly Turbine Locomotive for Swiss Federal Railways

THE increasing operating expenses resulting from the rising cost of fuel have given an added importance to locomotive efficiency. Careful study is not only being made of the means for securing an increase in the amount of work obtainable from the fuel used by locomotives of the usual type, but consideration is being given also to the possible substitution of locomotives of a radically different character. The high efficiency of the steam turbine and its rapidly increasing adoption in the stationary and marine fields has caused a number of designers to attack the problem of adapting a steam turbine to the driving of a locomotive.

One of the most notable efforts now being made in this direction is that of Dr. Zoelly, the well-known turbine engineer and general manager of Escher, Wyss and Company, Zurich, Switzerland. A 4-6-0 type locomotive of the Federal Swiss Railways has been converted by the Swiss Locomotive Works at Winterthur from a standard type locomotive with the usual reciprocating steam engine to a turbine-driven engine.

A Zoelly turbine of special reversible type was placed forward of the smokebox, the power being transmitted from the rotor by means of 30 to 1 gearing to a transverse jack shaft above the front truck. The connecting rods were extended forward and coupled to crank pins on discs located on either end of the jack shaft. The turbine was designed for a speed of 8,000 r.p.m. which corresponds to a running speed of 48½ m.p.h.

The boiler is provided with a superheater and a condenser is located between the frames The cooling water is taken from the tender and after passing through the condenser is returned to a longitudinal pipe underneath an elevated hood built over the tender, from which it is sprayed in narrow streams. The air currents formed by the moving locomotive furnish an effective means of recooling the water.

The condensate, which is pure and free from oil, is pumped back into the boiler, it being necessary to add only sufficient fresh water to make up for the losses from the safety valves, whistle and leakage. By continually using the condensed water for feeding the boiler, the formation of scale is practically eliminated. The condensate which is at a temperature of about 125 deg. F. is passed through a preheater and raised to about 250 deg. F. before it goes into the boiler.

As there is no exhaust pipe a blower is used to furnish the necessary draft. The control is by means of three valves, one for the ordinary forward operation, another for starting and for heavy pulls on grades and a third for running backward. The water capacity of the tender is comparatively small as the evaporation of the water while being cooled is only a small loss.

The trial runs which have thus far been made are reported to have shown a saving of some 25 per cent over similar compound locomotives handling the same trains. It is also reported that the running was remarkably smooth, due doubtless to the absence of reciprocating parts. The results of these experiments as well as those now being made by others in Sweden and other European countries will be watched with interest by American engineers.

Essentials of Progressive Motive Power Policy*

Recent Improvements in Locomotives Afford Opportunities for Reducing Transportation Costs

By G. M. Basford

LOOK back a bit. Only a short time ago—only a lifetime—people were 20 days on the road from New York to Buffalo if lucky, if wheels lasted and oxen or horses did not break legs and if food held out. It is different today, when a few hours of luxurious comfort brings us over these few miles with speed and security.

But I am going to say that we do not use our transportation blessings as well as those pioneers used theirs. We have the wonderful steam locomotive. It was here when those pioneers really began to build our great West. But now we have a new steam locomotive. It has been made new in our time, but we are not taking advantage of it. From an efficiency and economy standpoint the new one is as far ahead of that of 1835 as the one of that date was ahead of oxen and horses. If this appears to you to be an exaggeration you must lose no time to learn what has happened in our generation.

Those pioneers had "engine failures" with their Prairie Schooners; they were family tragedies. We have them now. We should not. The Prairie Schooner was not "bought on price." Quality and performance was the thing. When you place performance ahead of price you may have locomotives that will save the railroads.

How often important contributions to the solution of problems, if not the actual solutions, lie so near us that they are overlooked. How often we seek a panacea when what we need is something we already have but do not appreciate! Of this there is no better example than that of the steam locomotive of this wonderful, resourceful country. One of our most vital needs today is the application of good American common sense in allowing the locomotive to play the part it is completely ready to play in the reduction of the cost of transportation, providing we establish suitable locomotive policies.

With respect to the locomotive "policy" means a charted course using all established and safe aids to bring the craft to its logical destination. That destination is "the most tons moved for the least money." After "policy" there must be a plan based upon the fundamental principles of the policy and then a program to execute the plan.

Engineering Improvements Should Be Utilized to Cut Costs

No matter what else we do ours will be a sorry sort of railroading if we fail to find in the treasurer's office the results of the efforts of those who have spent the past 20 years in showing how to increase locomotive power per pound of metal and per pound of coal and who have proven their ability to do it. I say 20 years but it is more than 30 years since this work began. Some of the men who inaugurated this development builded better than they knew. I am thinking particularly of David L. Barnes, George S. Strong, M. N. Forney and H. F. Shaw.

They have many able successors who have worked with factors unknown or undeveloped in the days of engineers who lived a generation ahead of the rest of us and two generations ahead of their own contemporaries. These successors have produced big powerful locomotives, both freight and passenger, that surpass the highest flights of imagination of the men mentioned. For example, a passenger locomotive that will produce at the rate of a cylinder horse power per hour from 16.5 lb. of water and 2.20 lb. of coal and that weighs 121 lb. per cylinder horse power. This was done ten years ago. Lots of engines have been built since that time that cannot do as well. Another example is a magnificent big freight engine with 90,000 lb. tractive effort that will produce one cylinder horse power from 15.4 lb. of water and 2.00 lb. of coal and that weighs 90 lb. per cylinder horse power. This has been done. Do those to whom they mean most know these facts? Do they make full use of them? These are isolated cases showing possibilities, but current practice is far behind them. Every new engine on every railroad ought to be designed and built to equal and surpass the records just referred to.

It is most important to all of us to know the reason why the locomotive on most of our railroads falls so far short of what it may be, should be and must be if American railroads are to "make good" in the present emergency.

Locomotive Improvements Have Far Reaching Effects

Right now railroad officials are striving to increase efficiency and reduce cost as they never did before. Results in car loading and train loading have been great. But no matter what else is done to increase efficiency and reduce cost, bear in mind that improvement of the locomotive augments the effect of every other improvement that can be made. Everything done to make an engine pull more tons per ton of its own weight and per pound of fuel burned helps everything else you do to improve the efficiency of transportation. These facts are not as prominent in the minds of operating officials and of executives as they should be. Why? The locomotive today at its best is not understood by those officials as it should be. Why? Locomotives in everyday service may be made to produce at the rate of less than three pounds of coal per indicated horsepower. Why are so few of them doing this? Can they be made to do it? By co-operation, yes!

Motive power matters must be presented, discussed and decided on a new and appropriate basis. A man of wide experience has said "Whatever the locomotive can do, the railroad can do." As the business of the road is moving trains, that business will be most successful when the mover of trains, the locomotive, is what it should be, is designed, built, operated and maintained to the best advantage.

One of our difficulties is that we are so close to the locomotive as to tend to regard it as we always have regarded it—as a machine that we know all about. We did know all about it as it was in our boyhood but unless we have kept step with the improvements of recent years in locomotive matters we are far behind the times.

We are slow in taking advantage of money making improvements. Forney used to say "The human mind resents the intrusion of a new idea." This is true. The slow progress of locomotive improvements in this country proves that he was right. Europe and Canada led us in the introduction of the greatest improvement that the locomotive ever enjoyed. Europe has 14,000 applications of another improvement that is only just starting in this country, and what country needs these things more than we do?

We need to bring our locomotive problem to the front. We need to elevate it to its proper place in railroading. We need

* A paper presented before the Central Railway Club, January 12, 1922.

to give it the attention it deserves. We need to discuss it and decide the questions it presents by and with men who know and who should and must be heard. Let me ask a few simple but important policy questions that call for answer on every railroad, that are being answered in part by some roads but not as a whole by any road.

Pertinent Questions Concerning Motive Power Policy

What is your policy with respect to locomotive improvements, those factors that collectively give you, according to speeds, from 30 to 80 per cent more power per pound of fuel than you can get from a plain engine? What are you doing about these things when you order new engines and what are you doing about applying them to old ones?

What is your policy with respect to locomotives that for the next 20 or 30 years will be in these services: heavy freight, fast freight, way freight, fast passenger, slower passenger, branch line passenger and freight, yard switching, transfer?

What is your policy and plan with respect to the design of new engines for these widely varying duties? Who decides their earning ability for their working life of 20 or 30 years?

What is your policy with respect to assignment of locomotive power to meet varying conditions of traffic, seasonal or emergency conditions? If this is not done by those who ought to know most about power matters there must be a reason for it.

How do you know just how many new engines to order and what type and capacity to order? Is there a plan for this that looks ahead to that which is coming and is framed on experience of the past?

How do you know that the latest new engines are making good? Do you test them and keep records to show whether your locomotive engineering policy is correct and whether you are making the money from your new engines that you ought to make?

What is your attitude toward locomotive improvements as to application to older engines? Are the applications scheduled after careful, complete surveys of the power and are the improvements applied by program, systematically? Then do you organize to educate the men in the best use of the modernized engines to get the utmost returns for the investment? When you apply a locomotive improvement that is good for 25 per cent greater economy are you sure that you get that economy?

What is your policy with respect to scrapping old power and also obsolete shop machinery? Is it done systematically to take advantage of improvements as Andrew Carnegie did? Did it pay Carnegie to do it?

Do you have and follow an engineering or business policy with respect to your locomotives as a manufacturer does with respect to his investment in his expensive machinery?

How do you know that the enormous investment in locomotives themselves and in the facilities for repairing them are employed to the best advantage? Do you, as one railroad official does, hire a man, a specialist, to organize the use of every locomotive item on which he spends $100,000 a year or more?

Do you know that the mileage engines are making is what it should be and may be? Are you hampering operations by the old time idea that each division is a separate railroad? A passenger engine recently made a run of 1,000 continuous miles without uncoupling from the train. Regular continuous runs of 400 to 600 miles are being made. Are your engines making above the average of 60 miles per day? Herein lies a gold mine.

Are you sure that shops, shop equipment, locomotive terminals and terminal equipment are adequate to get the power back into service promptly and keep it in service continuously until time for the next shopping?

Do you know whether the internal friction of the 2-10-2 type locomotive is greater than the formulæ of the locomotive designers indicate?

Do you know that new locomotives can be built with improvements in design that will permit of safely deferring increases in weight of rail and strength of bridges for years to come?

Are you aware of the fact that the biggest, most powerful passenger engines in the country can be replaced by others that will stress the track and bridges less than the present engines and yet give enough increase in pulling power to reduce double heading and that improved engines will start and pull heavier trains than have ever been put behind any engine yet constructed? I refer to usual main line traffic.

What policy are you following with respect to signaling in relation to locomotive improvements that permit of more rapid acceleration in starting out of sidings, out of yards and across crossovers? The entire question of block signaling, siding locations and location of water and coal stations is opened up anew by the ability to accelerate trains faster and to make longer runs for coal and water. Our railroads were built for the saturated steam locomotive without the vitalizing factors of today. Is your road coming up to date in its use of these epoch making operating factors? If you consider these as mechanical matters and if you regard signaling as a safety measure alone you are missing something. Operating officers —ask signal engineers and mechanical officials to help you operate the road. They are in position to help as they never have been before.

Do you establish a definite plan covering the next three or five years with respect to your locomotive program? Do you keep in mind the fact that new locomotives will last 25 or 30 years and that your record of intelligent grasp of railroading is to be read by others after you are gone?

In the matter of water stops—have you thought of the effect on operating cost of the capacity of tender tanks on freight engines? Do you realize that applying new design tender tanks carrying 15,000 gallons of water would beyond question save more money in direct operating results on some railroads than anything of equal cost that you can do to a freight engine on congested track today with the possible exception of the application of a booster?

Of all these questions the most important today in long range results are the ones that involve the locomotive in its relation to track and bridges and the locomotive in its relation to the use of fuel, but all of these items are important. They are not referred to critically but constructively. There is a way to answer all of them. Some of them already have been answered on some roads. There are men who know the answers. The thing to do is to make it easier for these men to be heard.

Improved Locomotives Demand Changes in Operating Methods

Our railroads were built for the locomotive of the past. They were and are operated in accordance with the locomotive of the past. But the locomotive has changed faster than the methods of using it. A new, refined, efficient power plant is available to take the place of the one that was merely big and heavy. Those who operate our railroads must learn what has happened. For their own sake, the sake of the properties and of the people they serve they must take advantage of the locomotive as it may be, not as it is, to solve the greatest problem they ever faced.

Mechanical men must prepare the case of the improved locomotive and that of the refined locomotive that is ready but has not yet been built. They must be ready to recommend improvements on the new basis—that of their effect on operation and operating costs. They must be ready to present the possibilities of the new locomotive in helping solve track and operating problems. This is merely a matter of preparing for presentation facts that they know thoroughly, but have not been encouraged to present. Mechanical men—perhaps a change in status of the locomotive is coming. Be

prepared. Your part in it is vital. Your preparation for it will hasten the change.

Then a way to insure not only the presentation but consideration, discussion and decision of the power problem must be found. The locomotive must be viewed from a new angle. We have been deficient in our conception of it, and of its proper place in operation of the road and in the transportation of the country. Some of us have considered it from the standpoint of a mere pulling unit, not thinking deeply as to anything but drawbar pull. Some regard it merely as a machine that they must take care of and have ready for call. Others have considered it from the standpoint of a power plant very much like any other power plant, as a unit by itself, built and therefore fixed as to improvements. To others the first expense involved seems to be most important. Some look at the expense of maintenance, and these are prone to regard the bookkeeping of the locomotive as satisfactory without a real bookkeeping balance that shows maintenance in terms of the tons the engine hauls. Its effect on track and bridges is the vital matter in the minds of others.

Many Cost Factors Affect Locomotive Policies

We must get people together to talk these things over and show that not one of these opinions taken alone is correct. When engines were small, rates high and wages low these various points of view were natural and were not dangerous, they are nothing less than dangerous now. We must wake up to the great necessity of a locomotive policy that will bring all views into line to permit the use of the best possible transportation machines, because the locomotive pulls everything that goes over the railroad. It must be designed, operated and maintained in accordance with broader business, engineering principles in view of the requirements and the known possibilities of achievement.

Coal formerly cost 90 cents and now costs $4.00. Rails formerly cost $21.00 per ton and recently $47.00 was the price. An engine "simple as a grindstone" is a mighty expensive article to operate today but thousands of them are running that may and should be made efficient by improvements that everybody knows about and everybody accepts as satisfactory. Why don't we use these to the limit?

These improvements have revolutionized the locomotive art. They will revolutionize locomotive operation. Let us hasten the day when the locomotive is considered as a real part of the great transportation machine. It is a big part of the transportation machine. Above all other things every part of a machine must fit each other part. Otherwise a machine is impossible. The locomotive must fit track, tunnels, terminals and other factors, the least change in which means prohibitive cost where bigness and weight and the increased power that go therewith must give place to improvements and refinement that render greater weights unnecessary. It is time to disregard first cost and think of ultimate cost, to forget the limitations of the past and to build anew for the future. It is time to build every new engine on a new plan—to build it for high power with efficiency. Nothing that is known to be worth while and that increases real efficiency should be omitted from a new engine.

An improvement costing $10,000 to buy and even as much as that to maintain each year is a good investment if it nets a saving of $50,000.00 a year. You know what it costs. You do not know what it saves. It is good policy to double the first cost and the cost of maintenance if thereby locomotives will haul enough more tons or make enough more miles to show figures on the right side. This is one way to cut out red figures. How really absurd it is to live as we do in "comparative" figures instead of in constructive figures.

How Shall Recent Improvements Be Utilized?

In its 50,000th locomotive the American Locomotive Company in 1911, over ten years ago, set a pace for Pacific type passenger engines. That engine has proved the success of careful design, use of improvements then available and incidentally of cast steel cylinders and light parts that saved nearly nine tons of weight. But this engine, today among the very best of its class, can be given 25 per cent more power in starting and at high speeds without excessive weight addition.

In its class I1s the Pennsylvania Railroad set a pace for heavy freight engines. Those railroads which have applied capacity increasing factors to their older engines have set a swift pace toward reducing the cost of pulling trains.

How shall the improvements that rendered these two efficient designs possible and also vitalized so many older engines be used to bring the locomotive to "its own" in the possibilities of the future?

To answer—Put the officials who know most about these matters, those who are closest to their progress, those who know most about the difference between the best locomotives of today and those of only a few years ago, put them in position to be heard. Let them understand that they will be heard and tell them to prepare their case accordingly. Today they are on the defensive. Change their status. Let the operating officers who depend upon the roadway and the power, present their problems that relate to both of these factors and then the great operating factors—power, signaling and operation—may be considered as a whole. Nothing new is needed, but a new way of tying these together is imperative.

Power matters are not the only ones that call for new methods. Operating, purchasing, mechanical, accounting, legal, traffic, track and personnel questions, all would benefit by a new deal in organization. If each of these broad divisions of policy on a large road were presided over by a vice president, if these vice presidents or on a small road the equivalent worked regularly and consistently together as a cabinet of highly trained specialists, if every important matter affecting operation were discussed by all these men—leaving to a senior vice president final decision, the thing now lacking would be supplied. The cabinet form of working together is the essential thing.

For example—one official is convinced that heavier rail sections are needed, or that certain bridges need reinforcement. He is probably of the opinion that locomotives will become heavier and heavier and that he must keep pace with the increase in weight. The officer in charge of power will show that for the immediate future increase in locomotive weight is not necessary, in fact, is wrong, and that he can build new engines more powerful but lighter and less destructive to the track than present ones. Operating men want more drawbar pull. To appreciate the possibilities of more power without excessive weight they should take part in discussions that reveal these possibilities. Some officers believe that with a certain amount of money to spend, the largest possible number of new engines should be bought. They may be shown that a smaller number of more efficient engines is the better and financially safer plan. Some officers find it difficult to see the necessity for investing liberally in shop tools, labor saving cranes and hoists, in ash pits and coal handling equipment. They would be quick to see the need and would give their support if they were shown how these factors affect operation. No officer considers first cost when "safety" is at stake. No officer would consider first cost as the real cost if he was a member of the cabinet, whose deliberations formed the basis for the broad policies for the future.

Factors That Will Improve the Economy of Locomotives

To be specific here are some of the factors that will come into the plan that a policy will compel:

Improved cylinder operation, higher superheat and improvements in cut off such as cut off control. Ask the officials

of the Big Four about their cut off control as a factor in operation and in saving. Are we to wait years before getting the benefit of what they have done? Why not get it now when we need it most?

Increased boiler efficiency through feed water heating using waste heat and by improvements that compel greater boiler power through improved boiler circulation.

Increased starting power by means of the booster applied to trailing wheels.

Increased starting power and higher power at speeds by means of increased weights on drivers made possible by reduced dynamic augment. Alloy steel parts and refined design render this improvement available.

Improved conditions of combustion by application of the latest developments of the locomotive firebox as a furnace. This means improved fireboxes, more extended use of firebrick arches and mechanical stokers.

Weight per cylinder horsepower may be materially reduced by locomotive designers who are given the order to do their best in this direction. Up to this time they have never had a chance to show what they can do. They have much to offer.

The time has come for these refinements and for many others that are very important but which are not specifically mentioned for lack of space. The time has come for the "free hand" to bring prevailing locomotive practice up to the economically high plane that a few isolated cases have shown to be easily attained.

Savings Will Justify Increased First Cost

The able engineers of the electrical companies long ago learned that the electric locomotive required facilities for its operation and its maintenance that however needed had never been given to the steam locomotive. They spoke. Operating officers and executives listened. They listened because electrification was new, interesting and mysterious. Furthermore, the necessary words had power behind them to compel attention. When trains were stopped by fuses blowing, the fuses being located in a signal tower with no night attendant, the president of the electric company called the president of the railroad on the phone next morning and the thing was fixed. Does the steam locomotive have such attention?

At present the electrical people are making good use of the prevailing oversight of the possibilities of steam. Is this to continue? Is the country to pay the price of this oversight? Are the electrical propagandists to be allowed to get away with even misrepresentations of the efficiency of the steam locomotive?

Consider the high regard in which marine men and manufacturers hold their power plants. They know their dependence upon the power that drives their business. They understand that the power plant that is driving all the time or most of the time must be of the highest type and the most economical, that it is a big investment and must be used accordingly, that ultimate cost, not first cost, is the real cost.

Recent years have brought to the steam locomotive improvements that are comparable with those in marine and stationary development. Marine and manufacturing operations have been rebuilt because of power plant and power distribution improvements. New operating methods must come as a result of the locomotive improvements we are talking about.

It remains to do on railroads the thing manufacturers have done—to build better locomotives, improve old ones and to operate them according to the new conditions these improvements themselves have created. In short, to save fuel and lots of money.

Our locomotive builders are the best in the world. They are building and will build what you want. Why not wake up to what you need and get it? Not only our builders but the concerns that have developed locomotive improvements that are so important have engineers at home and abroad preparing the best, the latest, and more than that, the practical plans needed for the future. One of the builders sent its highest engineering authority to Europe where he spent more than a year in the study of locomotive design and operation under high priced fuel conditions. Then he designed No. 50000, which ten years ago was a milestone in locomotive progress and for ten years has been a leader in locomotive practice in several ways. But nobody wanted it. That cornerstone has been allowed to be obscured by bushes. Other cornerstones have been laid. Are they to go the same way?

Let it no longer be said with truth that there is not a single steam locomotive today on the rails of our country that embodies and represents the best, and all the best locomotive improvements that are available and that have proved their ability to reduce the cost of American railroad operation, of which we are so proud.

Its expense is the most prominent feature of the locomotive. The cost of everything about it is the thing that counts. This is the reason why it is impossible today to build the most economical engine. Of course it costs more to build and to maintain an economical machine than a crude or wasteful one. But cost is only one side of the question. The performance is the real side. Ton miles per locomotive dollar is wanted and no one is getting that figure. "What does it cost?" is the question asked. Change this question. Ask—"What will it do?"

If I were a railroad man I would put on my engines every single improvement I could find that would net a clear 25 per cent on the investment, and there are lots of them that I believe will double that return. Then I would make sure that all concerned understood the construction, maintenance and operation of the locomotive under the new conditions. Next I would see that the improved locomotive was loaded up to and operated to the limit of its economy and saving capacity. Remember that locomotive improvements give the best returns the harder they are worked. I would ask the operating officer how fast he wanted to go and then tell him how much load to give the engine. It would be all the engine could handle in order to pile up ton miles per ton of coal.

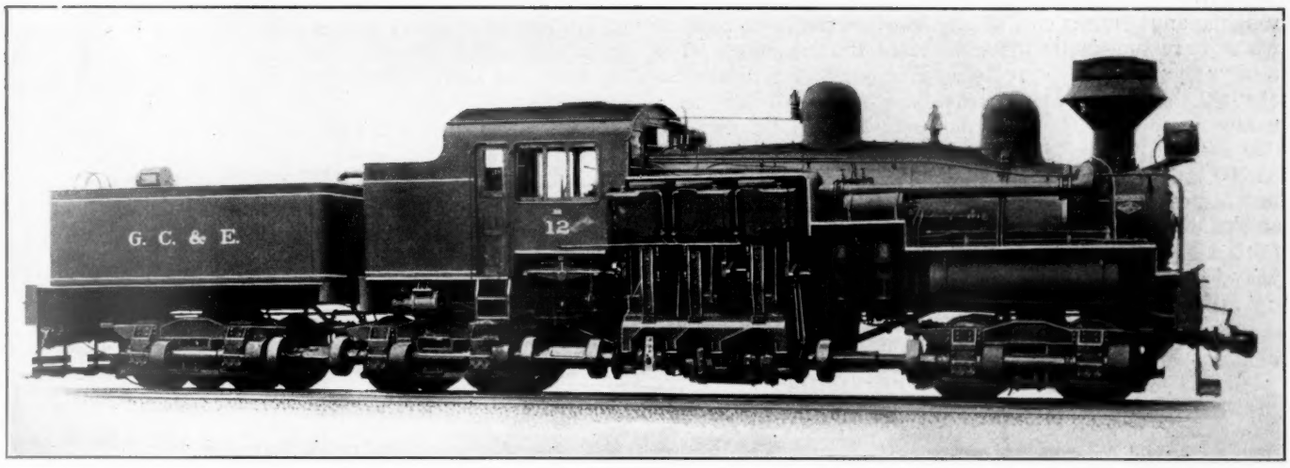
Supervision Needed to Get Results

This improved locomotive is different from the old "plain" ones. It will do more work or it will save fuel. To get these results requires more care, better handling by enginemen, better supervision and better operation. A few active young men could accomplish all this on any railroad and make every trip an engine runs a fuel test.

Talking "costs" without considering performance is a monumental mistake. It is my opinion that if the performance, in capacity and economy, of locomotive improvements were known, if individual locomotive fuel records were kept in parallel with ton-mile records, also for individual engines, the entire railroad organization would see a great light. "Acres of diamonds" lie at your feet.

Latent, potent, completely developed and successful but too little understood possibilities for the solution of one of our great problems lie at our very feet. To solve the problem of more tons moved for less money a policy is called for. Then there is no escape from the necessity for a plan followed by a program for its execution.

Cracks in Aluminum Castings.—In concluding a paper on Cracks in Aluminium Alloy Castings, R. J. Anderson, of Pittsburgh, Pa., says that the melting temperatures should be low; overheating in the furnace should be avoided. Open-flame furnaces should be run with a non-oxidizing atmosphere in order to avoid the formation of much aluminum oxide, and consequently occluded dross in the alloy. Skimming should be adequately and carefully done and the melting practice should be conducted as cleanly as possible. Foundry floor sweepings should not be charged into the furnaces unless sieved, and foreign materials should be kept out of the furnace charges. The pouring temperatures should be as low as is consistent with filling the mould readily with metal; high pouring temperatures should be avoided.



150-Ton Shay Geared Locomotive for the Greenbriar, Cheat & Elk

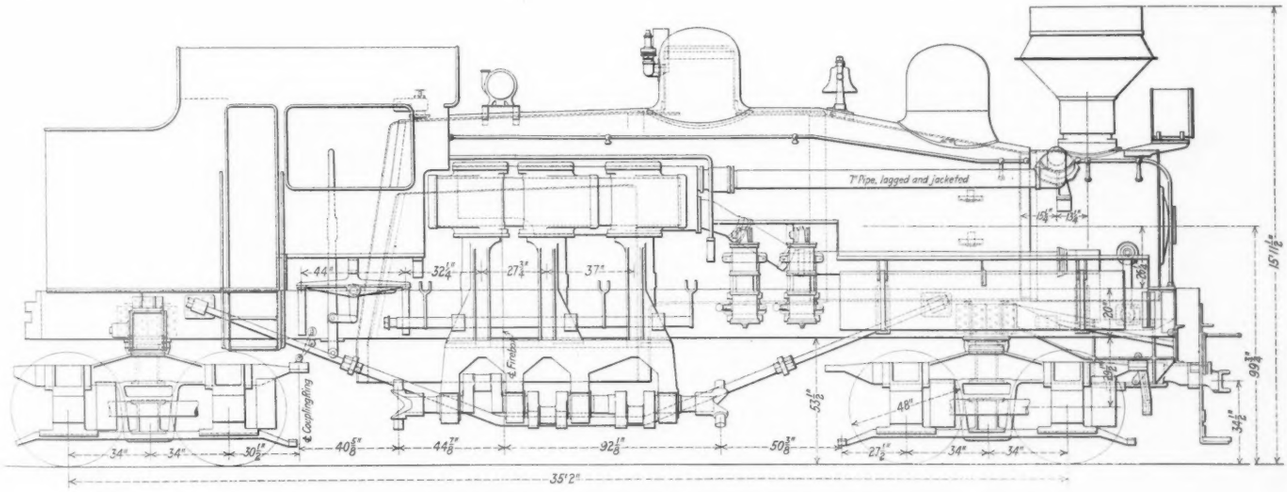
Shay Geared Locomotives for Mountain Roads

150-Ton Shay for Greenbriar, Cheat & Elk—High Sustained Tractive Effort Compared with Mikados

SHAY GEARED locomotives are frequently used on private railroads in rough country, for which service they are particularly suited. The entire weight of the engine and tender being utilized for adhesion, the locomotives are adapted for climbing steep grades at relatively low speeds, while the arrangement of trucks and flexible couplings in the driving shaft provides a short rigid wheelbase, which enables the locomotive to round sharp curves. Furthermore, the distribution of weights makes it possible to operate the locomotive satisfactorily on lighter rails and poorer track than would be possible with locomotives of the usual type.

The Greenbriar, Cheat & Elk Railroad operates between Cass and Elk, W. Va. The country through which the railroad runs is very mountainous and the use of many switchbacks is required to get over the mountains. There is practically no level or tangent track in the 115 miles operated either in the 85 miles of line or in the spurs. The grades are heavy and in many places are as much as seven per cent combined with 32 deg. curves. This combination of grade and curve makes it necessary to have a locomotive of high tractive effort, and at the same time with a very flexible wheelbase.

The freight hauled consists principally of logs, lumber, pulpwood and coal. These products are brought out over this line to the main line railroads for distribution to various points. The cars used are the standard flat or gondola types now in general use on main line roads. The road is laid with 85 lb. and 100 lb. rails, which allow the use of heavy axle loads in providing the necessary motive power.



Side Elevation of 150-Ton Shay Geared Locomotive

To meet the requirements of the freight traffic the Lima Locomotive Works, Inc., in conjunction with the officers of the railroad company, designed and built a 150-ton locomotive of the Shay geared three-truck type with a gear ratio of 1 to 2.45. This locomotive has been in service for several months hauling freight satisfactorily.

A comparison between the 150-ton Shay used on the Greenbriar, Cheat & Elk and the U. S. R. A. heavy Mikado

is exceedingly interesting. Table 1 shows the general weights and dimensions of the two locomotives, both of which have practically the same rated tractive effort. The total weight of the Shay locomotive, including tender, is 308,000 lbs., all of which is used for adhesion. The locomotive alone of the U. S. R. A. heavy Mikado weighs 325,000 lbs., of which 240,000 lbs. is used for adhesion and 85,000 lbs. is dead weight. The tender weighs 172,000 lbs. in addition, which brings the total weight of the locomotive and tender up to 497,000 lbs. This, possibly, is hardly a fair comparative weight as the capacity of the tender on the Shay locomotive is only about 60 per cent as much as that of the Mikado but in this connection it must be borne in mind

TABLE 1—COMPARATIVE WEIGHTS AND DIMENSIONS OF 150-TON SHAY AND U. S. R. A. HEAVY MIKADO

	U.S.R.A. Heavy Mikado	150-Ton Shay
Tractive effort (85 per cent)	60,000 lb.	59,740 lb.
Cylinders, number	2	3
Cylinders, diameter and stroke	27 in. by 32 in.	17 in. by 18 in.
Weights in working order:		
On drivers	240,000 lb.	308,000 lb.
On front truck	28,000 lb.	.....
On trailing truck	57,000 lb.	.....
Tender	172,000 lb.	.....
Total dead weight	257,000 lb.	.....
Total engine and tender	497,000 lb.	308,000 lb.
Maximum weight per axle	61,000 lb.	51,350 lb.
Wheel base, driving	16 ft. 9 in.	49 ft. 0 in.
Rigid	16 ft. 9 in.	5 ft. 8 in.
Total engine	36 ft. 1 in.	35 ft. 2 in.
Total engine and tender	71 ft. 9½ in.	49 ft. 0 in.
Driving wheels, diameter	63 in.	48 in.
Boiler, style	Con. Wagon Top	Ext. Wagon Top
Diameter, outside first ring	86 in.	62⅜ in.
Steam pressure	190 lb.	200 lb.
Firebox, length and width	120⅛ in. by 84¼ in.	114 in. by 61¼ in.
Grate area	70.8 sq. ft.	48.5 sq. ft.
Tubes, number and diameter	247, 2¼ in.	166, 2 in.
Flues, number and diameter	45, 5½ in.	26, 5⅜ in.
Tubes and flues, length	19 ft.	13 ft. 6 in.
Heating surface, firebox, including arch tubes	319 sq. ft.	226 sq. ft.
Heating surface, tubes and flues	3,978 sq. ft.	1,656 sq. ft.
Heating surface, total evaporative	4,297 sq. ft.	1,882 sq. ft.
Superheating surface	993 sq. ft.	411 sq. ft.
Tender:		
Water capacity	10,000 gal.	6,000 gal.
Coal capacity	16 tons	9 tons
Ratios:		
Weight on drivers ÷ tractive effort	4.0	5.16
Total weight, engine and tender ÷ tractive effort	8.28	5.16

that the boiler capacity is much less and the necessary tender capacity may be correspondingly reduced.

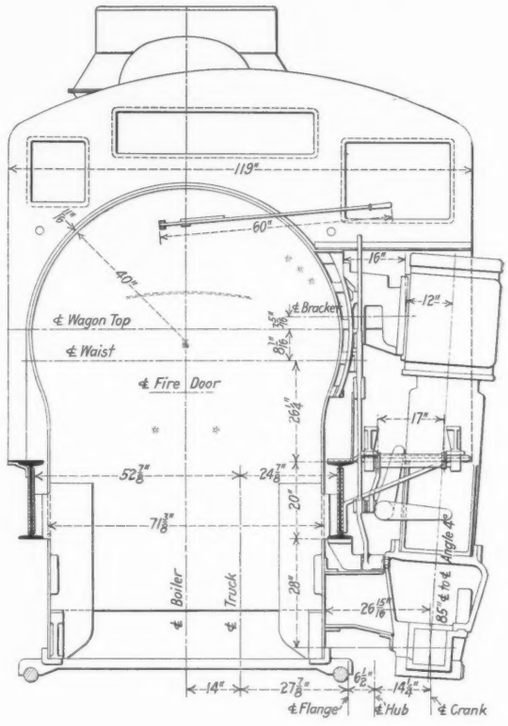
Further interesting differences in characteristics will be noted by comparing the drawbar pull on various grades as shown in Table 2. While both locomotives have practically

TABLE 2—COMPARATIVE DRAWBAR PULL UNDER VARIOUS SERVICE CONDITIONS OF 150-TON SHAY AND U. S. R. A. HEAVY MIKADO

	U.S.R.A Heavy Mikado	150-Ton Shay	Per cent
Tractive effort (85 per cent)	60,000 lb.	59,740 lb.	98
Drawbar pull:			
On level	56,000 lb.	58,500 lb.	104½
On 1 per cent grade	51,000 lb.	55,400 lb.	108½
On 2 per cent grade	46,000 lb.	52,350 lb.	111½
On 4 per cent grade	36,100 lb.	46,200 lb.	128
On 6 per cent grade	26,150 lb.	40,000 lb.	153
On 8 per cent grade	16,200 lb.	33,850 lb.	209
Sharpest curve for engine	300 ft. rad.	179 ft. rad.	60
Lightest rail advised	90 lb.	80 lb.	89

the same train starting capacity on a level track, the Shay locomotive is capable of exerting 28 per cent greater pull on a 4 per cent grade and more than double the pull on an 8 per cent grade. Furthermore, on a 4 per cent grade the drawbar pull of the Shay locomotive is still 77 per cent of the rated tractive effort, while the pull of the Mikado has fallen to 60 per cent, and the difference is still more marked as the grade increases.

The advantages of the characteristics of the Shay locomotive, low total weight, all the weight of the locomotive and tender used for adhesion, and high sustained tractive effort at low speeds on heavy grades make them a desirable type of locomotive under certain conditions. There are many places in main line service where pushers are required and also in



End Elevation of Shay Locomotive

branch line traffic where a Shay-geared locomotive could be used with advantage instead of the heavy direct-connected locomotives commonly employed.

Spanish Northern Railway Electrification Project

A contract for the electrification of 40 miles of the Spanish Northern Railway is announced by the Sociedad Iberica de Constructiones Electricas, of Madrid, Spain, one of the associated companies of the International General Electric Company, Inc., of New York. This initial order constitutes the most recent and one of the largest European railway electrification projects now under development. The high voltage direct current system will be used.

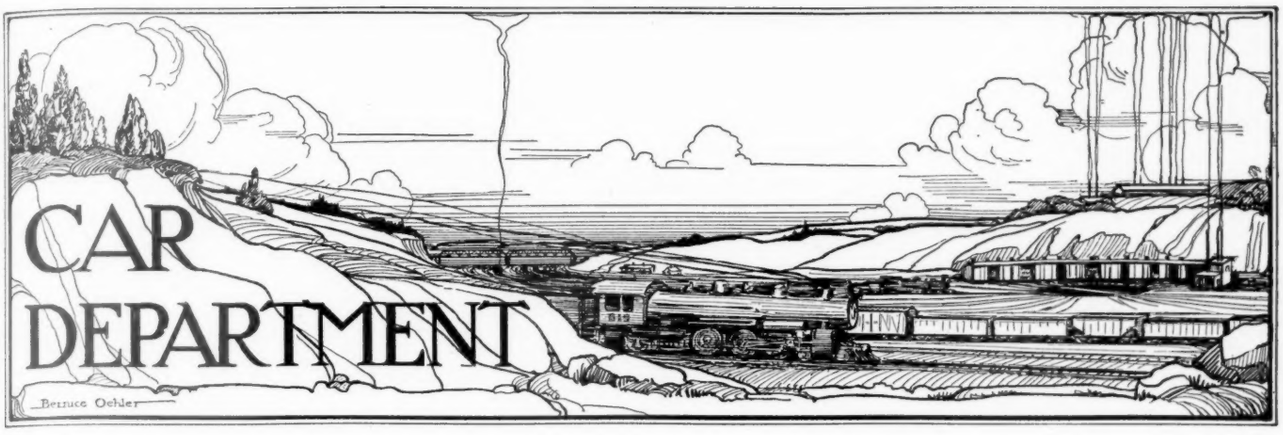
The equipment to be supplied by the Sociedad Iberica de Constructiones Electricas will consist of six 78-metric ton, six motor locomotives, two complete sub-stations, each comprising two 1,500 kilowatt, three unit motor generator sets, transformers and switchgear and the material necessary for line construction.

The first electrification project of the Spanish Northern comprises about 40 miles of the Leon-Gijon line running through the mountains between Ujo and Busdongo. Although this is a single-track line, traffic is extremely heavy, as it is a link between the mining district and the northern seaboard through a mountainous region with many tunnels, considerable grades and severe climatic conditions.

The electric locomotives on order will be of the freight type, with the following dimensions:

Length over buckles	46 ft.
Height	13 ft. 11 in.
Width of cab	9 ft. 8 in.
Rigid wheel base	11 ft. 6 in.
Maximum wheel base	35 ft.

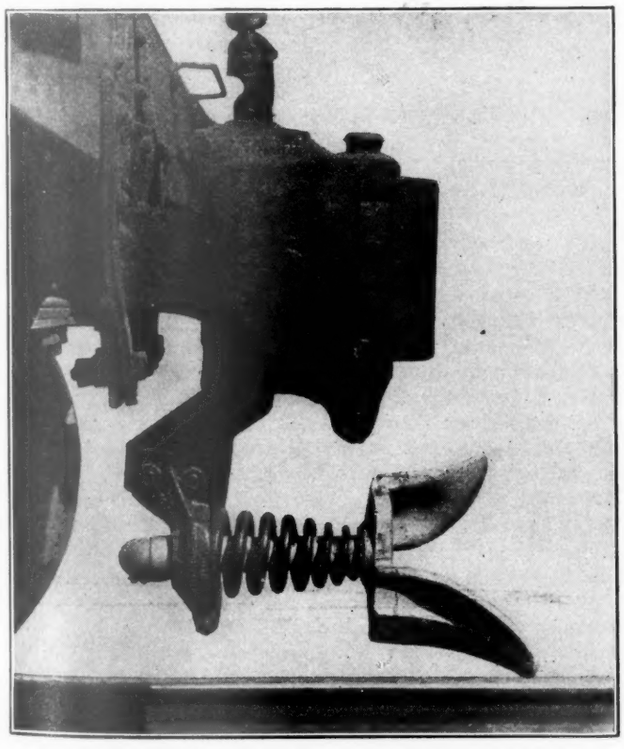
The locomotives will be arranged for regenerative breaking, and will operate at 3,000 volts. The locomotive speed at continuous rating is 13.5 miles an hour. Pantograph collectors will be used similar to those on the St. Paul locomotives, having a double contact shoe.



The Development of the Robinson Connector

Latest Type Incorporates Improvements Suggested by Extensive Service of Earlier Design

THE coupling and uncoupling of cars, either passenger or freight, involves two operations: the engaging or disengaging of the couplers and the connecting or disconnecting of the train lines. The former operations are semi-automatic and are controlled by levers conveniently located at the sides of the car; the latter, however, must still be performed by hand, a method which involves some danger to the employees because it is necessary for them to go between the cars. Coupling train lines is one of the duties of the car inspector which consumes a considerable share of his time. Uncoupling the train line, which should be done by hand, is often neglected and the hose are allowed to pull apart when the cars are separated.



The First Design of the Robinson Connector, Type A

The loss of time in connecting hose and the bad effects of pulling them apart have led railroad officers to look to the automatic train line connector as the solution of these and other difficulties. In discussing the automatic connector a leading railway master car builder said: "There appears to be no room for argument about the need of such a device. The greater life of hose, the absence of broken train pipes resulting from uncoupling cars without first disconecting the hose, the saving of time and labor in making up trains, and the reduction in the cost of pumping air, all of which might be classed as direct or apparent economies, would undoubtedly justify the cost of application alone, but the writer is even more impressed with the benefits that would be secured indirectly. Numerous leaks are found in hose and gaskets at all seasons of the year, almost entirely the result of the practice referred to above; viz., pulling the hose apart, thereby injuring the fabric and inner tube. In the cold weather, however, when the hose freezes, the difficulty in preventing air leakage becomes a controlling factor in the operation of long freight trains and they have to be reduced in length to a point where the air pressure can be maintained irrespective of the tonnage rating or the ability of locomotives to haul them. Even at the best, this factor is responsible for a very great amount of terminal detention and labor on the part of car men trying to stop leaks.

"The connector increases the life of hose because it eliminates all mechanical wear. The hose is never jerked or strained. Frozen hose does not interfere with its operation and leakage and breaks are cut down to such an extent that it is possible to run longer trains."

The problem of the automatic connector was considered by the Master Car Builders' Association in 1908. A committee on this subject submitted a report which recommended a butting type connector with pin and funnel gathering device. From the time this report was issued until the present the Master Car Builders' Association and its successor, the Mechanical Division of the American Railway Association, have given little attention to this subject, although a subcommittee was organized in 1919. In this interval, however, there had been a remarkable development in train line connectors. Since 1910 over 1,000 cars have been equipped with the Robinson connector. Its present performance is

such as to command careful consideration and as a history of the development of the device is essential to an understanding of the present state of the art, an account of the successive stages through which it passed will accordingly be given.

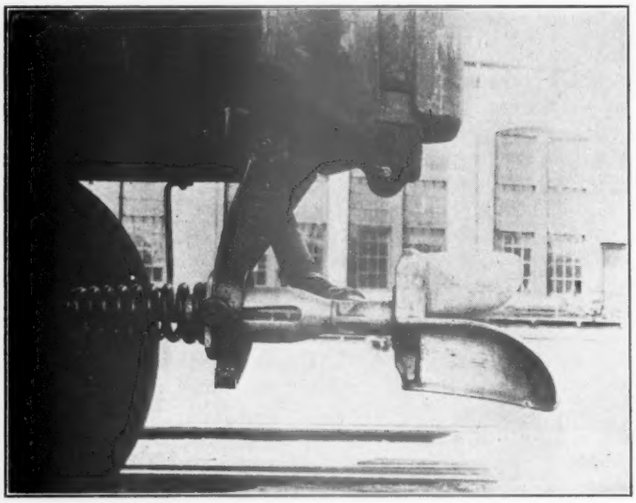
History and Extent of Service

In 1910 the first design of Robinson connector was applied to a passenger work train operating on the lines of the Washington Terminal Company, Washington, D. C. Its service extended over a period of ten months and was satisfactory to the railroad officers in charge. Representatives of the Interstate Commerce Commission watched the installation and were so well pleased with it that the commission arranged for an official test of the connector on the lines of the Great Northern at Grand Forks, B. C.

The test was made on the Marcus division of this road, extending between Grand Forks and Phœnix, B. C. The trains hauled were heavily loaded ore trains. Fifty cars were equipped and run interchangeably with 140 unequipped cars. The grade was 3.3 per cent and the curvature in some places excessive, curves of 22 deg. being commonly encountered. Railway officers from various parts of the country were present; the Board of Railway Commissioners at Ottawa delegated representatives, and every conceivable test was made of the connector, each of which it met successfully.

The Robinson Connector Company also tried out in the Great Northern tests a connector with a pin and funnel type gathering arrangement. The experience with this design indicated that it was not satisfactory because it was deficient in gathering range and also because dimensions when once fixed could not be altered. Consequently, no further experiments were made with this type.

These tests definitely established at least one important fact; that this connector made and maintained a perfectly tight joint, thus greatly increasing the effectiveness of the air brake. In submitting its official report on the test of the



Type B Robinson Connector

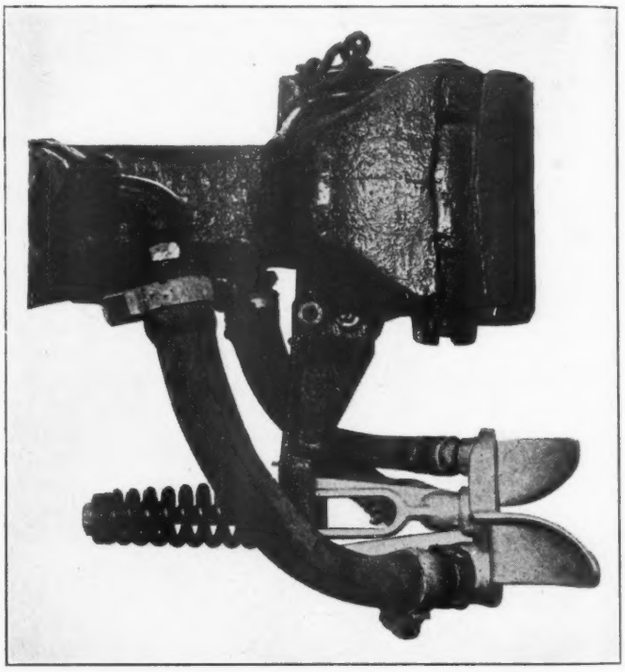
Type A connector the Interstate Commerce Commission concluded as follows: "From information obtained in this test the conclusion is reached that the Robinson connector is a safe and practical device, which if properly installed and maintained, will meet the need for an automatic connector in general freight service and add to safety in train operation on the railroad using it.

"It is mechanically simple in construction and composed of few parts which are easily assembled. It is comparatively light in weight, and of ample strength to withstand all shocks to which it is likely to be subjected in ordinary service. Its gathering range is sufficient to meet all variations between cars in service where car couplers can be made to operate, and it will withstand severe distortion without damage when heads are forced together under conditions where car couplers will not operate.

"It will maintain a tight joint between connector faces, even when gaskets are worn to such an extent that they could not be used with the standard hose coupling, and its use would materially reduce train pipe leakage."

Freight Connectors Installed on Canadian Northern

In view of this report by the Interstate Commerce Commission and in view of the favorable opinion of the con-



Type C Robinson Connector for Passenger Service

nector expressed by its representatives, the Canadian Board of Railway Commissioners became interested in the device and requested the Canadian Pacific, Grand Trunk Pacific and the Canadian Northern to look into it.

As a result of this request four all-steel hopper cars on the Canadian Northern were equipped with freight connectors of a new design, known as type B. These connectors were installed by the Canadian Northern at its Winnipeg shops in May, 1914, and put in continuous service handling gypsum rock from Steep Rock to Winnipeg during the summer and in coal service between Port Arthur and Winnipeg during the winter months. These cars ran in this service for three years under the most severe track and weather conditions, especially in winter, the temperature from December to March ranging from 10 deg. to 45 deg. below zero. The test came to an end through a wreck on the Steep Rock line, destroying all four cars. No change of hose or gaskets had been made during the whole period and these parts were in good condition at the completion of the test. Reports issued each trip by the train crews handling these cars show no train leakage whatever and all concerned were greatly pleased with the device.

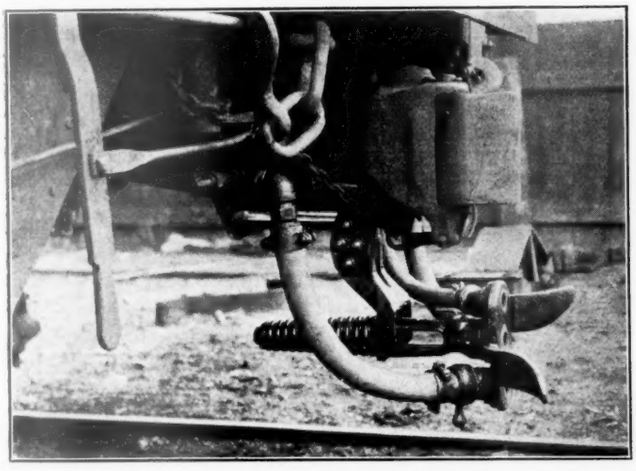
The second installation in Canada was made by the Canadian Pacific, which equipped one passenger train in service between Montreal and Ottawa in February, 1915, with type B connectors. This test proved satisfactory and resulted in equipping 125 passenger cars operating out of Place Viger terminal, Montreal to Quebec, Ottawa, and Eastern Quebec

points. These cars were equipped with the type C, an improved design incorporating changes suggested by experience with types A and B.

The Grand Trunk Pacific in April, 1915, equipped one passenger train in service between Winnipeg and Transcona, and three Hart cars in freight service between Fort William, Ont., and Transcona, Man., type B connectors being used. These tests were satisfactory and reports show the high esteem in which the connector was held by Grand Trunk Pacific officers.

Type C Connector in Passenger and Freight Service

In May, 1915, the Canadian Northern equipped a passenger train running between Wininpeg, Man., and Edmonton, Alta., which continued in service until March, 1917, under the most severe track and weather conditions to be found in America. During the winter of 1915 and 1916 temperature went as low as 55 deg. below zero in parts of Saskatchewan. This test proved so satisfactory that the Canadian Northern ordered equipment for 250 passenger cars and 200 freight cars, the latter to be used on the Duluth, Winnipeg & Pacific out of Virginia, Minn.



Latest Design of Passenger Connector, Type 2 H

The new type C connector was supplied for these installations and the freight cars were equipped in February and March, 1917. The 200 cars equipped were steel flat cars in log service between lumber camps of the Virginia & Rainy Lake Lumber Company and Virginia Mill. On the lumber company's lines cars were handled over skeleton track, an abnormally severe condition not to be duplicated in railway service, but the connectors operated satisfactorily without any sign of leakage. Between Virginia and Cusson, on the Duluth, Winnipeg & Pacific main line, cars were handled in complete trains of 40 cars and showed such a remarkable decrease in troubles due to train line leakage that all concerned were impressed with the advantages of the connector, especially in winter weather. No leakage whatever was found in the connectors, whereas similar trains operated over the same line and equipped with ordinary hose couplers showed continual delays on account of creeping brakes and poor brake operation due to train line leakage.

In 1920 two New York Central passenger trains and three locomotives on the Valley division at Dunkirk, N. Y., were equipped with type C connectors, where they continue to give satisfactory service. At about the same time 50 steel hopper cars, engaged in copper ore trade, were equipped on the Mineral Range at Calumet, Mich. The installation operated under extreme climatic conditions, such as excessively deep snow and very cold weather, and was discontinued only because the mines were forced to close through bad market conditions. The officers of the road who came in contact with the connector were greatly pleased with its service.

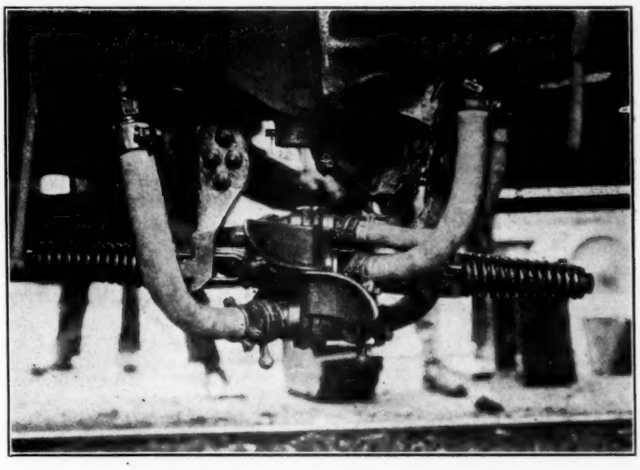
Extensive Installation in Through Passenger Service

From March, 1917, type C passenger connectors continued to be installed on all Canadian Northern trains operating west from Winnipeg, and further orders were placed by this road during 1919 and 1920, when all passenger equipment west of Montreal to Vancouver, B. C., was equipped. This covered trunk line operation amounting to 12,000 miles of railway and included transcontinental trains of 12 to 14 cars each, operating between Montreal and the Pacific Coast, a distance of 3,000 miles. This large installation was the first real trunk line operation ever attempted with any connector and resulted in experience with regard to the requirements for automatic connectors never before obtained.

As the result of this extensive experience, and the study given to connector design for more than 12 years, the Robinson Connector Company has developed a standard connector, embodying advanced features and refinements of design which only long and varied experience could make possible. While differing in refinement of details from the old type C connector, the same fundamentals of connector construction are found in it. It is stronger and more rugged; the gaskets are removable from the rear of the coupling head without parting the cars and the head is somewhat larger in anticipation of changes in the steam heating system now being advocated by many railways.

Objects of the New Design

The objects which the Robinson Connector Company has sought to attain in the new connector are primarily the following: (a) a coupling head of size adequate to permit such needed developments in the head as time may demonstrate to be desirable, without affecting interchange with previous heads; (b) simplicity and speed in the renewal of defective gaskets without parting the cars; (c) a more rugged and powerful bracket and lug foundation for the connector; (d) a spring compression sufficient to compensate for the excessive wear between car coupler knuckles occasionally encountered; (e) increased size in the steam port opening; (f) a reduction in the number of gaskets used; (g) a greater gasket life; (h) to convey the air and steam through the connector head without it contacting with the head, thereby eliminating the necessity of making the head of air-tight material; (i) simplification of interchangeable manufacture.



Type 2 H Connectors in Coupled Position

The first of these objects has been attained by increasing the length and width of the head to 11½ in. and 5 in.

respectively. Within this space the three ports may be arranged in any one of several ways. They may, for instance, be cored in the head or they may be formed of separate fittings and suitably mounted in the head, as in the case of the air brake port. These dimensions will readily accommodate any size of port which future developments in the air or steam line are likely to require. The air and signal ports may be increased to 1½ in., and the steam port to 2 in. opening without affecting interchange with previous heads.

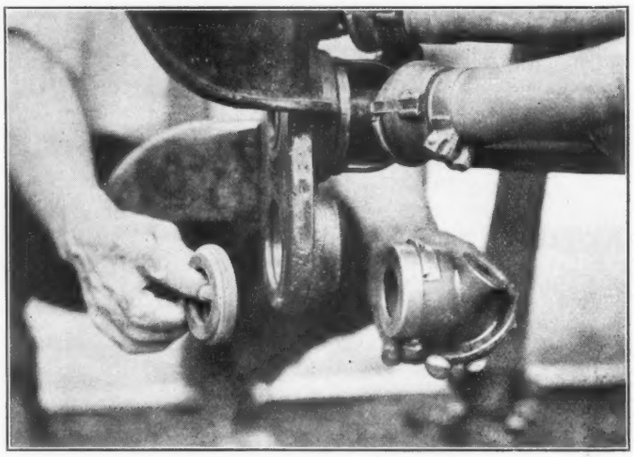
Flexibility of Gathering Range

Another important feature of this type of coupling head is the flexibility of its gathering range dimensions. While there is very little about connector design that is not now known to connector manufacturers and to railroad men who have studied the question, it has not yet been determined what gathering range a connector should have to accommodate most efficiently the varied requirements of service. It is known, of course, that the passenger connector requires a greater gathering range than the freight. The passenger car being much longer, with a considerably greater overhang from truck center to end sill of car, the angle at which the connectors approach is more acute, and hence the gathering range must be greater. But since the conditions under which passenger cars operate are practically known factors, it is not a difficult matter to determine what gathering range the passenger connector should have.

With the freight car conditions are different, however. There are a great many different types and many different lengths of freight cars. They operate under the most severe conditions, being commonly hauled over track on which it would be impossible to run a modern passenger car. Moreover, freight cars receive the minimum of maintenance. These factors complicate the problem of determining what gathering range is most suitable for the freight connector. A dimension has been developed that has so far proved satisfactory, but how it would meet general freight service on hundreds of thousands of cars, only extensive installation can reliably tell.

The magnitude of the field for the freight connector and this inherent element of uncertainty as to one of its most important dimensions, point with emphasis to the necessity for a gathering range which may be varied at will without affecting interchange with previous units of the equipment.

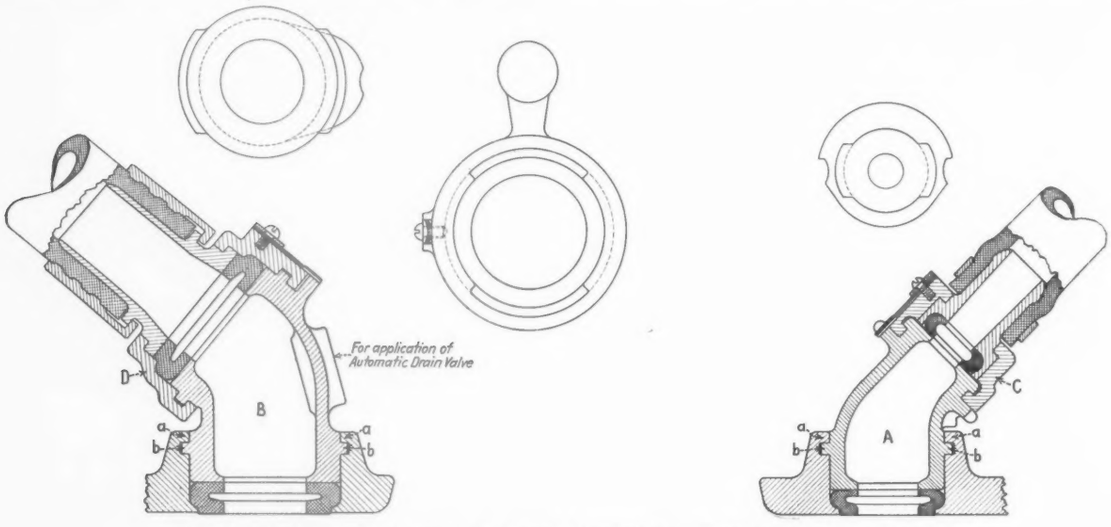
This cannot be done with any type of pin and funnel connector. It is an inherent limitation in all pin and funnel heads that a gathering range once set cannot be changed. The freight and passenger gathering range cannot be dealt with separately with the pin and funnel head. The freight head must be as large as the passenger head, otherwise they will not interchange. A great waste of material and unnecessary bulk to the freight connector arises from this fact.



Steam Connection Removed to Change Gasket

These are among the reasons which led this company to discard the pin and funnel head.

Flexibility of the gathering range dimensions is an inherent advantage of the wing type of head. The spread of the wings may be increased or decreased at will, with a corresponding change in the gathering range without affecting interchange with previous heads. The freight head, having but a single port, may be made to size and be given a gathering range best suited to freight operations, and yet interchange perfectly with the passenger head. The only dimension common to the two heads is the width of the face and the location of the wings with respect to the ports.



Details of Steam Heat and Air Signal Connections, with Removable Gaskets

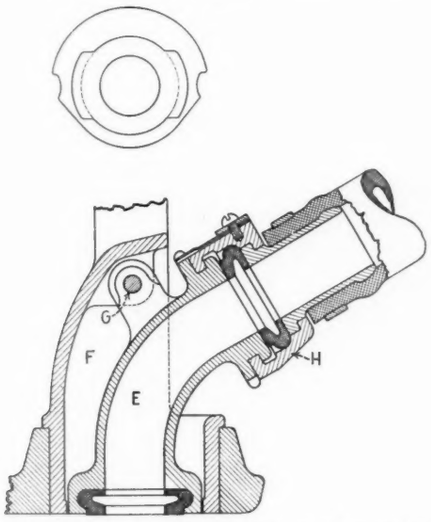
A great economy in first cost and maintenance results from this flexibility of design which avoids the necessity of putting metal that is not required into the freight head simply to get it to interchange with the passenger head.

All Gaskets Readily Removable

The second object, simplicity and speed in the renewal of defective gaskets without parting the cars, is attained in the new connector by mounting the signal and steam port gaskets in the face of the head and backing them up by the curved

fittings *A* and *B* shown in the illustration. These are removably mounted in the head by a bayonet joint comprising dogs, *a*, on the head behind which the lips, *b*, on the fittings are rotated. The unions, *C* and *D*, for connecting the hose to these fittings are formed in a similar manner.

When it is desired to remove a signal or steam gasket the hose unions are opened and the fittings *A* and *B* are rotated out of the head. This exposes the gaskets which may then be readily removed through the rear of the head. Normally, each of these gaskets is under slight initial compression; in design they are of the air-expanded type. Thus, when the air or steam is admitted the gasket swells into absolutely



Details of Removable Brake Pipe Connection

air tight engagement with its seat in the head and against the front face of the fittings *A* and *B*.

The removal of the brake port gasket is accomplished by a somewhat different process. Here the gasket is mounted in the forward end of a curved fitting *E*, removably held in the connector pipe, *F*, which is pressed with the head, by a pin, *G*. When removal is desired, the pin is lifted and the entire fitting is removed from the connector. To accomplish this it is not necessary to open the union, *H*, by which the brake hose is attached to its fitting. This union is employed solely to facilitate interchange with a car not equipped with the connector. When the interchange period is over the union will be eliminated and the hose mounted directly upon the rear end of the fitting. This produces a simple and efficient air line arrangement.

Improved Design of Bracket and Lug

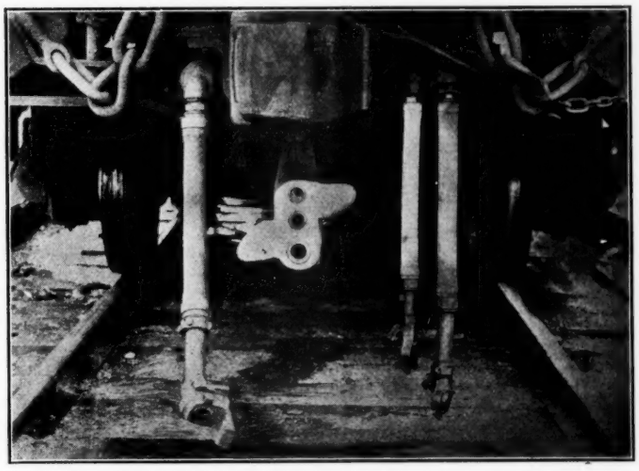
The third object, a more rugged and powerful bracket and lug foundation for the connector, is accomplished by lengthening the lug by which the connector bracket is supported from the car coupler. In the new connector the leverage ratio on the lug bolts has been reduced from 6 to 1 to 2 to 1, and instead of two bolts, four are used. The result is a dependable and powerful foundation for the bracket, a most important consideration.

The fourth object, a spring compression sufficient to compensate for the excessive wear occasionally encountered between car coupler knuckles, is attained by the use of a longer buffer spring and by increasing the length of the connector pipe. In the previous connector this compression was 1½ in., but long experience demonstrated that on account of excessive wear occurring in some coupler knuckles, this was insufficient. It was therefore increased to 2½ in., which permits of the maximum wear on the car coupler knuckles without affecting the rigidity and tightness of the joint between the connector heads when coupled in the slightest degree.

The fifth object desired was increased size in the steam port opening. In the previous connector this opening was 1½ in., which is the dimension widely employed for the present hand-hose coupling. The difficulty incident to properly heating long trains in excessively cold weather has brought about considerable discussion looking to a greater steam port opening. Since many railroad men are of the opinion that the steam port opening must ultimately be increased, an opening of 1¾ in. has been adopted in the new connector. This dimension, however, permits perfectly satisfactory interchange with a connector head having a steam port opening of 1½ in.

The sixth object, a reduction in the number of gaskets used, is attained by using in the steam union the same gasket that is used in the steam port, and by using in the signal port, the brake port, and the brake union a common form of gasket. Thus in the freight connector but one type of gasket is used, a convenience of much practical importance.

The seventh object, a greater gasket life, is attained by giving greater body to the gaskets. In the previous connector



Robinson Connector Fitted for Interchange with Standard Hose Couplings

the air gasket had a face width and a depth of ¼ in., while the width of the steam gasket face was ⅜ in., and the depth of this gasket was ¼ in. In the new connector, the air gasket has a face of ⅜ in. wide and the steam gasket a face ½ in. wide. The gaskets are also deeper than the previous design, and the increase in size and resiliency insures longer life.

The eighth object, to convey the air and steam through the connector head without bringing it in contact with the metal of the head, is attained by the improvements previously mentioned. It will be observed from the drawings that the contents of each of the train lines is carried through the head without imposing any fluid pressure on the metal in the head and hence the requirement for an air-tight casting in the head is eliminated. In the case of the brake line, always, of course, the most important line, the air is carried through the head by the fitting *E*. Eliminating the necessity for making the head of air-tight material not only greatly facilitates its production and lowers its manufacturing cost, but makes it a much more efficient part.

The ninth object, simplification of interchangeable manufacture, is brought about mainly by the dimensions and design of the head of the new connector. Various developments may be made within the head without affecting interchange with previous units of the equipment. Forming the gasket seats in the manner shown and mounting the fittings in the head instead of making them an integral part of the head, not only simplifies foundry procedure, but greatly simplifies and reduces machining costs. From this simplification greater ease in maintaining interchangeable dimensions in the several parts naturally results.

Results of Scheduling at Milwaukee Coach Shops

Simple System of Standard Schedules Developed Under Adverse Conditions Lead to Record Output

ONE of the comparatively few shop scheduling systems recently applied in other than locomotive shops has been in operation for the past year at the Milwaukee, Wis., passenger car repair shops of the Chicago, Milwaukee & St. Paul. Although so simple that the full time services of but one man are required for its administration, the system has had a marked effect in increasing output and in doing so has met with no opposition from the men employed.

The Milwaukee shops differ from many coach repair shops in that no track capacity outside the paint shop is available either for stripping or finishing. From the time the work of stripping is started until a coach is finished ready for service it occupies a track inside the paint shop. Hence the total length of time each piece of equipment is in the hands of the shop forces directly controls the output of the shop. No attempt has been made to develop a scheduling system in complete detail for the purpose of following each item of repair work through the various departments, but the utmost care has been used to develop schedules for the work which must be done on the car so that there shall be no interference of one craft with another and that the sequence of the operations of the various crafts shall be arranged to reduce the total time in the shop to the smallest number of days possible.

There are 11 standard schedules in regular use calling for from 14 to 24 days in the shop. The schedule illustrated is one of the six, the length of which varies from 14 to 24 days, that cover practically the entire range of repair work in connection with ordinary painting operations. The other five schedules, varying from 17 to 24 days in length, are for application to cars calling for complete paint renewal, starting with burning off or sand blasting. It has been found that with the exception of diners, business cars, sleepers, etc., the outside carpenter work and paint work will determine the length of time required in the shop. Particular care, therefore, has been given to the working out of the carpenters' and painters' schedules and these crafts are carefully checked for strict adherence to them. In the case of some of the other branches of work only the finished date is given, leaving the handling of work which is actually removed from the car, largely at the discretion of the foremen. Adherence to the finished date of all crafts is checked and appropriate action taken in case the frequency of failure to make the schedule indicates laxity or the need of some adjustment.

In repairing sleepers and other high class cars (the C. M. & St. P. operates its own sleeping and parlor cars), should none of the regularly established schedules fit, parts of one schedule are combined with parts of other schedules or new schedules are worked out as circumstances require. Wrecked cars on which there is an exceptional amount of repair work are not scheduled until the point has been reached where part of a schedule can be applied with reasonable certainty that its requirements can be met. No schedule is applied to cars taken in for light repairs.

Aside from the master schedules, to which reference has already been made, the only forms used in the administration of the system are the weekly lists, showing the in and out dates, track location, the class of repairs and schedule designation of each car in the shop; a checking form, one for each car, for the use of the schedule man in noting operations on time or late in a daily check of the shop, and a list of operations overdue or completed ahead of time, issued at the close of each working day. The weekly list is particularly useful to the foremen of outside departments as it gives them all the information necessary to tie their work into the master schedule. In addition to this form the foremen working directly on the coaches have access to the shop blackboards,

WORKING DAYS IN SHOP	PAINTERS		CARPENTERS		CABINET MAKERS	TINSMITHS	TRUCKS	STEAM FITTERS	AIR BRAKES	ELECTRICIANS	UPHOLSTERER	SILVER PLATERS	MACHINIST	WORKING DAYS IN SHOP
	OUTSIDE	INSIDE	BODY	PLATFORM										
1			Strip	Strip	Strip		Off							1
2	Wash	Wash									Stock Recv'd	Stock Recv'd		2
3			Start	Start	Start	Start Roof								3
4														4
5			Finish		Finish					Finish				5
6	Prepare	Start												6
7	Prepare			Finish							Finish Roof			7
8	Prepare													8
9	Color #2													9
10	Color Varnish					Roof Finish								10
11	Ornament													11
12	Varnish #1													12
13	Dry	Finish						Pipes Finish Cover & Test				Stock Finish		13
14	Paint Bottom Varnish #2				Start Trim					Dyn. Set up & Electric Board			Dyn. Set up	14
15							On ℄ Level							15
16	Paint Roof	Touch Up (Afternoon)			Finish Trim (By Noon)	Trim (By Noon)			Finish & Test	Batteries OK Dyn. Fin. Test			Dyn. Fin. Test	16
17		Clean (By Noon)	Car O.K. for Service at Noon							Tested (By Noon)	Trim Finish (By Noon)			17

Typical Master Schedule, Milwaukee Passenger Car Repair Shops

Shop Blackboard, One at Each Stall in the Coach Shop

one at each track, on each of which is entered all essential information relative to the car to which it applies.

The adoption of a set of standard schedules covering a sufficiently wide range of conditions to meet the requirements of the majority of cases has simplified the working of the schedule system. These schedules, blueprinted and bound in book form with a set of simple rules and explanatory notes, are distributed to all persons concerned with the administration of the system. Before a piece of equipment is taken into the shop a schedule is selected and applied by the general foreman after an inspection. The routine work consists principally of a daily check of the shop, making up the daily list of operations overdue and ahead of time and preparing the weekly list of equipment in the shop. This is handled by the schedule man under the direction of the shop engineer.

That ideal shop conditions are not essential for the successful application of the scheduling system, provided it is adapted to local conditions, is evident from the experience at the Milwaukee shops. The present scheduling system went into effect on October 1, 1920, practically at the beginning of the general falling off in traffic movement which led to a universal drastic curtailment of maintenance expenditures. In common with other railroads the Chicago, Milwaukee & St. Paul has worked its shops on short time and with reduced forces during most of the year's experience with the scheduling system. Notwithstanding these unfavorable conditions, excellent results have been obtained.

During the 33 months beginning with January, 1918, a period ending with the establishment of the scheduling system, 1,627 cars were turned out in a total of 830 working days, an average of 1.96 cars per working day. This was a period of practically full time operation, averaging 25.1 working days a month with an average output of 49 cars a month. During the first year of scheduling 572 cars were turned out in 191.9 full working days, an average of 2.995 cars per day with an average of but 16 working days a month. The increase of daily output, amounting to 52.8 per cent, is attributed to the scheduling system. In addition to the scheduled cars in for heavy repairs, an average of ten cars a month have received light repairs.

Prior to the war, from 1901 to 1917 inclusive, the monthly output of the Milwaukee shops averaged 24.5 cars. The highest monthly output during the period was 49 cars. In October, 1920, the first month of operation under the scheduling system, 74 cars were turned out for general repairs which constitutes a record for the shop. In June and July, 1921, the output averaged 3.5 cars each working day, the highest daily average ever obtained.

Furthermore, the increased output has been obtained with less men. The number of men employed on passenger car work averaged 1,122 during the year of scheduling as compared with 1,157 during the first nine months of 1920 and 1,362 during the year 1919. Under the scheduling system 375 men were employed for each car turned out daily as compared with 548 in 1920 and 711 in 1919.

The reduction in the number of working days that cars are held in the shop to undergo general repairs has varied from 0.5 to 8.6 days per car, depending on the class of equipment. The average reduction in the case of steel coaches has been 8.6 days per car, for steel underframe express cars 7.3 days, for wooden milk express cars 6.3 days, and for full vestibule wooden coaches, 5.3 days.

The Preservative Treatment of Car Lumber

Practical Results So Far Obtained Suggest the Desirability of an Extension of the Practice

By H. S. Sackett

Assistant Purchasing Agent, Chicago, Milwaukee & St. Paul

A SIGNAL virtue of wood which alone makes it more suitable for general car construction than steel is the readiness with which it may be protected against natural deterioration or decay by chemical treatment. This is accomplished before placing in the structure with positive assurance that it will be serviceable for the full mechanical life of the part. Steel must be continually painted with rust- and acid-resisting paints to protect it against early failure because of corrosion.

Prior to the last few years very little attention has been given to the influence on car maintenance of decay in wood members of freight cars. Car builders were prone to charge a great majority of failures to mechanical causes. It developed during an exhaustive investigation conducted for a period of two years by a special committee of the American Wood Preservers Association, that the contrary was more to the point.

Analysis of a questionnaire distributed through the Master Car Builders' Association indicated that at least 30 per cent of all repairs to freight cars of all-wood or composite construction were directly due to decay.

This information was, of course, generally based on the experience of the car foremen who supplied it, and it may be assumed that but little care had been given to gathering data that would be conclusive. An effort was made, therefore, to check the estimated figures as provided in the committee report* for which purpose a special clerk was placed by one of the committee members in a western car repair shop, whose experience could give accurate judgment as to whether decay or mechanical failure was the primary cause for the respective repair or replacement.

An interesting fact developed incidentally in this investigation was that during the month that this special inspection was in force 1,100 steel cars and 399 wood cars were repaired at the shop in question. As the shop is located in a section of the country where wood equipment still predominates it may be significant.

It was shown that of a total of 265,666 individual parts or pieces replaced, 82.3 per cent failed directly because of decay, and 17.7 per cent represented mechanical failure. The repairs were distributed approximately as shown in the accompanying table.

The types of cars included in this investigation, which constituted the regular run of bad order cars turned in at this particular shop, were distributed as follows: box, 223; coal, 87; ballast, 23; flat, 20; refrigerator, 19; stock, 17; tank, 10.

These data when submitted to car builders, have caused much astonishment and, perhaps, some doubt. There may be circumstances which would not allow of their application, in toto, to all other shops in the country. However, there is no record of a similarly thorough investigation at any other

*See the proceedings of the American Wood Preservers' Association for 1910.

point, and it is prudent to give very careful consideration to the facts here disclosed.

The main fact that is gleaned from these data is that the preservative treatment of car lumber is necessary as a matter of straight economy and essential as a conservation measure. This is merely another instance where reasonable precaution—maximum efficiency in utilization—would materially increase the durability of cars as a whole and reduce the cost of maintenance, thus in many cases making unnecessary the substitution of more costly steel equipment. In other words, in the past we have not obtained the maximum service from wood because of our negligence in applying comparatively inexpensive remedial measures and have, therefore, not really learned the ultimate value of wood for the several purposes under consideration.

DISTRIBUTION OF REPAIRS OR RENEWALS OF WOOD CAR PARTS BY CAUSES

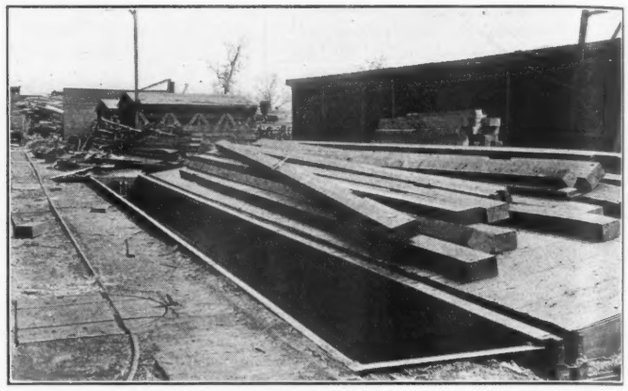
Description of part	Causes of failure: Decay, per cent	Causes of failure: All other causes, per cent
Draft timbers	0.0	100.0
End sills	34.4	65.6
Deadwood	7.4	92.6
Long sills	68.0	32.0
Sub-sills	26.2	73.8
End posts	32.4	67.6
Coal car sides	80.1	19.9
Running boards	97.3	2.7
Roofing	100.0	0.0
Siding	89.5	10.5
Lining	89.1	10.9
Decking	95.4	4.6
Grain strips	96.5	3.5

Small Tank for Creosoting No. 1 Common Yellow Pine Decking and Roofing; 250 to 400 Pieces Per Charge Immersed 30 Min.; Repairs Caused by Decay Already Reduced More Than 50 Per Cent

It is true that certain changes in present shop practices must precede the introduction of treated timber in car construction; but that is a comparatively unimportant detail when the more costly changes which the adoption of all steel equipment would necessitate are considered. The latter would not only entail new shop practices but complete reorganization and almost entirely new tools and equipment or rather, duplication of machinery because the composite cars built during the last five years or so would require maintaining the present shops for their repair. Consequently, by following lines of least resistance and choosing the lesser of two evils, if they are to be considered such, immediate adoption of treated car material is a good policy and fits in well with the present desire and need for economy, wherever that may be practicably applied.

Treated material can be used in practically every type of car. Whenever creosoted timber is not suitable because of the fear of contaminating lading, the lumber may be treated with zinc chloride, sodium fluoride, etc. Methods of treatment are standardized and each standard treatment has its own record of achievement under suitable circumstances. There exists no insurmountable obstacle to the practice of wood preservation in car construction.

Refrigerator cars have been in service for between 7 and 10 years with treated sills. At first they were brush treated with creosote and when this had proved worth while the sills were creosoted by the open tank process. To the treated sills were added creosoted sub-flooring and roofing for the undercourse. More important still, never have the owners received a complaint that lading has been contaminated, although some cars of the latter type have been in meat service for over a year.



Open Tank Creosoting Plant for Treating No. 1 Common Yellow Pine Car Sills; Treated Sills Show No Decay After Four to Six Year's Service

When speaking of treated timber for freight cars one naturally thinks first of stock cars, and these surely provide the greatest opportunity for saving in this direction. Stock cars with creosoted sills and decking have been in service for about 12 years without a single repair due to decay, where untreated stock car decking fails in from 4 to 6 years and sills in from 5 to 8 years. However, this is not the limit to which treated materials can be used in this type of car. Practically the entire car should be treated, from sub-sills (on steel underframe cars) to the roof. Where stenciling is necessary that can be applied to special boards, or it can be taken care of by the use of metal numerals and signs, the cost of which would be a small item in comparison to the saving derived from the use of treated lumber.

Condition of Stenciling Applied to Creosoted Surface After Eighteen Months' Service; Surface Prepared by Applying One Coat of Pure Shellac

Coal cars, flat cars, logging cars, caboose and housing cars

all offer the same opportunity for economy by protecting the wooden parts against decay. Of box cars the sub-sills and nailing strips may be creosoted and the decking treated with sodium fluoride or zinc chloride where proper facilities are available. It may also be that other parts of box cars could be treated with these latter preservatives, but on that point there exists too little information at this time to allow a definite recommendation.

The particular advantage in addition to obtaining increased service is that preservative treatment allows the use of lower grades of wood, especially the presence of a goodly percentage of sapwood. In fact, sapwood is a partial advantage as it is more absorbent, takes treatment more readily and, therefore, gives greater protection to the stick.

Some shops are applying creosote oil to points of contact of sills, posts, etc., and the specification for the box cars developed during the war required treatment at such points with either paint or creosote. This is a step in the right direction, although paint cannot be considered a preservative in that it does not possess the necessary toxic qualities to inhibit the development of wood destroying fungi, or to kill the spores thereof that may be present on the surface and in the checks of the timber. However, it must be remembered that the value of any preservative treatment is in proportion to its thoroughness. Practically all car shops could equip themselves at little expense to employ the open tank process, and some roads operating pressure treating plants could arrange for the treatment of car material at these plants. The means for the practice of wood preservation, either by the use of surface treatments, the open tank process, or by employment of material treated at commercial or railroad plants with the standard pressure processes, are available in such varied form that no reasonable excuse can be advanced for continuing the abuse and waste of wood due to preventable decay. No repair yard, carpenter shop, or construction point along the railroad but can secure a barrel of creosote and a brush and at least partially protect such wood as it used against decay. As to the technical information involved, that likewise is readily obtainable and can be assembled by every engineering department and reduced to practical instructions to the workmen to bring about the desired results. Consequently, no extended discussion of these details need occupy us at this time. Suffice it to repeat that this is one means by which railroads can save enormous sums now expended for repairs that could be postponed or prevented were the lumber given the proper opportunity to serve its full period of usefulness by the simple expedient of protection against decay, applied before placing in the structure.

Car Inspectors Discuss New Rules of Interchange

Meeting at Chicago to Arrive at a Uniform Understanding of Changes Effective During 1922

FOR the purpose of arriving at a common understanding of the American Railway Association code of interchange rules, as revised in 1921 and now effective, a one day meeting of the Chief Interchange Car Inspectors' and Car Foremen's Association was held at the Great Northern Hotel, Chicago, on January 9. The meeting was called to order by the president, E. Pendleton (C. & A.), and proceeded immediately to the consideration of the changes in the rules. On completing the discussion of the changes, other questions pertaining to the rules were taken up and a lively discussion of delivering and receiving line liability for the cost of transfers under Rule 2 and Car Service Rule 14, resulted.

At the opening of the afternoon session, President Pendleton called the attention of the members to the death of Henry Boutet on April 25, 1921, since the last meeting of the association, which was organized at a meeting called by Mr. Boutet at Cincinnati in March, 1898, and of which he was president from 1905 to 1911 inclusive.* A committee was appointed to draft suitable resolutions in honor of Mr. Boutet and in appreciation of his work in the early upbuilding of the association.

No association business was transacted. An abstract of the discussion of the rules follows:

Rule 1 now reads:

RULES 1 AND 66.

Each railroad is responsible for the condition of all cars on its line, and must give to all equal care as to inspection, *oiling, packing* and repairs, regardless of responsibility for expense of repairs.

E. H. Mattingley (B. & O.): There is a question on the interpretation of Rule 66 as it now is written and it might be well to discuss that before we get away from Rule 1. Rule 66 now reads:

All journal boxes should be repacked when necessary, using properly prepared packing (new or renovated), in accordance with A. R. A. Recommended Practice, at which time all packing should be removed from the boxes and boxes cleaned; dust guards to be renewed (if necessary) or replaced when wheels are changed.

The date and place (railroad and station) where the work is done should be stenciled on the car body near the body bolster at diagonal corners in 1-in. figures and letters, using the same station initial that is used for air-brake stencil.

No change should be made in the stenciling unless all boxes are repacked.

Why should it be necessary to repack all the boxes on the car and stencil them if you are not going to get paid for it?

C. J. Wymer (C. & E. I.): I think the intent of that rule is that the boxes are supposed to have thorough attention at least once in 12 months.

Mr. Mattingley: Is it the consensus of opinion of this Association that in the case of a foreign car bearing a stencil "Boxes packed, January, 1921," if received on a car track January, 1922, the line having the car in its possession would be supposed to repack those boxes and restencil the car under Rule 66 and Rule 1 as they are now written, without making any charge?

A. Kipp (N. Y., O. & W.): I do not understand that there is any obligation now on any railroad to repack the foreign car. We are going right back to 40 years ago. If the packing in the boxes on the car is suitable to the service that you are going to put the car in that settles it. You can repack or not, just as you like; and with the elimination of the pay for the repacking of the boxes there will be little of it done.

F. W. Trapnell (Kansas City, Mo.): Rule 66 says "should be"; it does not say "shall be." It leaves it optional with you to do as you please in the matter; and if you do not think the boxes need repacking at your expense, you are not going to pack them.

Mr. Herring (Southern): As I read the revised rule there isn't any date specified.

Mr. Mattingley: When are you going to repack the other fellow's car when it is on your line?

Mr. Herring: When it is necessary.

Mr. Mattingley: When is it necessary?

*Mr. Boutet's obituary appeared on page 412 of the June, 1921, *Railway Mechanical Engineer*.

Mr. Herring: That is at the discretion of the handling line.

Mr. Mattingley: The Recommended Practice of the A. R. A. is every twelve months.

E. S. Smith (Florida East Coast): As I understand that rule, it reads they shall be packed when necessary, but they shall be packed in accordance with the M. C. B. Recommended Practice for the care of the journal box packing.

Mr. Parkin (Kansas City, Mo.): Mr. Mattingley says that twelve months was to be the time, but that was in the 1920 rules. In the 1921 rules they left it out and therefore it becomes obsolete.

A motion was made that it be the consensus of opinion of the Association that under Rules 1 and 66 it be left to the discretion of the handling line as to when journal boxes shall be repacked. The motion was carried.

RULE 2.

Interpretation.

Q.—Can a car be refused on account welded truck side which may have been welded previous to January 1, 1920?

A.—Rule 2 gives the receiving line the right to refuse any car which in its judgment is unsafe for movement on its line. It is assumed that this question concerns a truck side with a defective weld.

Mr. Mattingley: It is my opinion that under this interpretation a car with a welded truck side not defective and welded previous to January, 1920, must be accepted in interchange. If in the opinion of the receiving line the weld is defective the car must be transferred at the expense of the delivering line. This would also apply in case of cracked or broken frames.

A. Armstrong (Atlanta, Ga.): Rule 2 gives the receiving line the right to refuse a car which has a defective truck side. That still is a matter of judgment. There is not one per cent of the welded truck sides on which the work is done in accordance with Rule 23.

Mr. Mattingley: Do I understand that if a car is offered in interchange with welded truck frame, or a defective truck frame, that car can be transferred, if loaded, a transfer order issued against the delivering line and the car returned when empty to the delivering line, regardless of the length of crack or percentage of the fracture?

T. J. O'Donnell (Buffalo, N. Y.): You are reading into the interpretation something that should not be there. The Arbitration Committee has given the most logical interpretation that can be given as to the defect and the requirements of the welds. It tells you that you can refuse every car that rules permit you to refuse. I really think that we should leave that just as the arbitration committee has ruled on the interpretation. I am surprised that Mr. Mattingley should want to refuse and transfer a car for a little defect in one of the truck sides.

Mr. Mattingley: Other interpretations have been rendered by that committee in connection with this rule that have not been lived up to. If in my judgment I should refuse a cracked truck frame where the crack is a ½ in., ¾ in., or 1 in. long am I entitled to a transfer order and am I entitled to return the car to the delivering line, according to this interpretation?

Mr. O'Donnell: I should say no. You might just as well say you refuse a car with a ¼ in. crack on your center sill.

Mr. Mattingley. If my judgment says a 1-in. crack or a ½ in. crack is unsafe, I am perfectly entitled, under this interpretation, to refuse the load and return the car.

Mr. Wymer: Mr. Mattingley is right and Mr. O'Donnell is right. I think there is too much technicality in various places in the country. I recently handled some papers where cars had been transferred for cracks after the car had made some 1,200 miles with a load of meat, and reached pretty near its destination, the delay originated claims. This technicality is costing the railroads money in the way of claims unnecessarily.

Mr. O'Donnell: Our mechanical engineers have told us at what percentage we can weld and at what percentage or over it is better to take the truck side out and scrap it. Why go before the interchange points throughout the country and make something else? If you are going to say that you have a perfect right to transfer cars for anything below 1½ in. you are going to put a club in the hands of your inspectors and they are going to use it to the disadvantage of the business. There is too much transferring for slight defects in truck sides already. There ought to be more welding outfits to get the loads through without transferring the cars. In the last few years I have not seen one of those truck sides fail. According to the rules I have got to give the money against the delivering line when the car is refused, irrespective of whether it can be welded or not if the receiving line says it is not convenient for it to maintain the welding outfit.

F. C. Shultz (Chicago): We have taken the position that inasmuch as the Arbitration Committee has made a rule by which a truck frame can be welded unless the fracture exceeds certain limits or is too close to a previous weld, it can be applied to a load, and we have refused to issue transfer orders.

Mr. Mattingley: I claim that the rules give me the right as the representative of the Baltimore & Ohio to refuse any car with a fractured truck frame or a welded truck frame that in my opinion, as its representative, is not safe to go over its line. Do not conflict the requirement of Rule 23 with Rule 2. Rule 23 simply tells how to perform the work, and under what conditions to weld and not to weld, and has nothing to do with the acceptance or refusal of the car.

Mr. Shultz: The only question now is whether or not you can consistently repair a fractured truck frame within the Rule 23 while the car is under load. That is the only question at issue. You do not have to disturb the contents to do it. If you do not see fit to provide facilities to do it that is your disability, in my opinion.

R. A. Kleist (B. & O.): Rule 2 does not require you to weld a truck frame under load, and a transfer order should be given. Whether the welding can be done or not does not matter.

The Chair: The interpretation that is placed on this rule, in my opinion, is entirely clear and I believe Mr. Mattingley's contention is absolutely correct.

Mr. O'Donnell: I move the following resolution: The chief interchange inspectors in interpreting the rules feel that the utmost efforts must be made to maintain the metal truck sides in accordance with Rule 23, but when conditions warrant transfer of the lading the receiving line can apply Rule 2 and the delivering line be held responsible.

The motion was seconded and carried.

Mr. Fitzgerald: The second paragraph of section (c), Rule 2, reads:

Cars of 80,000 lb. capacity and over, equipped with A. R. A. Standard axles, may be loaded to maximum shown in Column "A" of Rule 86, which is the total weight of car and lading for the respective capacities given.

The table in Rule 86 quotes the varying capacities of cars and includes the 60,000-lb. capacity cars.

A 60,000-lb. capacity car with new steel sills and metal ends, if loaded to more than 95,000 lb. would be too heavy on the journals. The loading rules and Rule 2 permit you to load to 66,000 lb. load capacity but if you take the light weight of the car with the weight of the betterments added, you would exceed 95,000 lb. on the rails and overload the journals. I believe there is an interpretation which is not now covered in these rules.

Mr. Gainey: I believe that came out in the rules of 1916 or 1917. The arbitration committee said they based the weight of the car on the journal and that you could not load a 60,000-lb. capacity car to more than 95,000 lb. total weight.

Mr. Fitzgerald: Will all concerned agree that the 95,-

000-lb. limit shall govern us in interchange of equipment? If a 60,000-lb. capacity car, loaded to 66,000 lb., weighs more than 96,000 lb., under rule 86 we are entitled to reject the car, but Rule 2 refers only to 80,000-lb. capacity cars and over.

R. J. Overton (Southern): You will note the loading rules allow 10 per cent in excess of the stenciled capacity of a car. With the average weight of the 60,000 car something like 35,000 lb., that would make a total of 101,000 lb.

Mr. Gainey: In some parts of the country they are transferring cars if the gross weight is over 95,000 lb. Other places are paying no attention to it. They are letting it go up to 106,000.

Mr. Fitzgerald: I believe in the 95,000-lb. limit because the journal is designed at a certain factor of safety to carry that weight. If we agree to observe Rule 86 and forget about Rule 2, it would be generally understood that those cars would not move if loaded over 95,000 lb. light.

Mr. Overton: This question has come up in several ways on the Southern and our mechanical engineers have taken the stand that they are going to be governed by the 10 per cent excess of the stenciled capacity of a car, on 60,000 capacity cars regardless of the total weight on the rail.

Mr. Cheadle: I know of a number of cars recently reaching our line of the old wooden construction with non-A. R. A. axles where the load weighed 66,000 lb. and that weight added to the light weight of the car exceeded 95,000 lb. In other words, that was a heavier load on the non-A. R. A. axle than A. R. A. axles are supposed to carry under Rule 86. The practice in our territory is to be governed in transferring the cars by the transportation department. They tell us whether the car is overloaded or not and we transfer it according to the information we get from them, because they have the bills and in the average railroad yard the car inspector has no access to them.

Mr. Fitzgerald: I move that it is the sense of this meeting that we be governed strictly by Rule 86 so far as the loading of the car is concerned.

The motion was seconded and carried.

Rule 2 and Car Service Rule 14

Mr. Halbert: Rule 2 and Car Service Rule 14 show what the delivering and receiving lines' responsibilities are in the transfer of loads. Rule 2 (e) does not require the acceptance of loaded cars in interchange "when cars can not pass approved third rail clearances or overhead clearances for electrical conductors of the American Railroad Association." We have had quite an argument in our territory over that and I would like to hear the opinion of this body as to who is responsible for the transfer in that connection.

Mr. Wymer: Section (d), Rule 2, says the delivering line will pay the cost of transfer of lading of open cars when dimensions of lading are in excess of published clearances of roads over which the shipment is destined. Now, section (e) refers to approved clearances of the A. R. A. They have certain approved clearances, I think, in regard to the third rail, etc., which I do not think have anything to do with the clearances of an individual railroad.

Mr. Halbert: Rule 2 (d) takes care of the lading on open cars. Car Service Rule 14 (e) has a foot note which says the word "cars" covers both closed and open cars, but not the lading. The foot note comes under an item for which the receiving road pays the cost of transfer or rearrangement, but paragraph (e) especially calls attention to paragraph (d) and I made the decision that the delivering line was responsible for the transfer of a load from a car that is too high or too wide to pass the published clearance of any railroad which the car goes over.

William House (Southern): Car Service Rule 14 says the receiving road shall pay cost of transfer or rearrangement when the cars cannot pass clearances, except as provided in paragraph (d), or when cars cannot be moved through on account of any other disability of the receiving line. Rule 2 (d) refers only to the lading on open cars. If a line delivers a box car too high for an A. R. A. third rail clearance, and would be at the expense of the delivering line. But if that box car is found too high for the individual published clearances of the line over which it is going to travel, it is up to the receiving line to transfer that car at their own expense.

Mr. Halbert: If a car is too high or too wide to pass the published clearances of the receiving line, which are published monthly I understand, according to Rule 14 (d), I think the receiving line is entitled to a transfer.

Mr. Armstrong (Florida East Coast): At Miami, Florida, a furniture car is loaded almost every day. Is it my business as a car inspector to note what lines it will pass over before it gets to its destination?

President Pendleton: I would consider that it is your duty to inform the agent that the car will not pass the published clearances of the roads over which it is to travel and he would be responsible for the cost of transferring before it reached its destination.

Mr. House: Suppose a Santa Fe box car is loaded in the Far West, consigned to St. Louis, and there it is reconsigned and routed over the Southern. Between St. Louis, Mo., and Louisville, Ky., the Southern has four tunnels. We find that it will not clear these tunnels, and we cannot run it. Is it proper to penalize the delivering line for the cost of transfer because we cannot run it or is the Santa Fe supposed to build cars that will clear our tunnels?

This question came up for discussion at Louisville among the car foremen at that point and they ruled as Mr. Halbert did, that the delivering line should pay the cost of transfer. The Monon took exception, the matter was investigated and went to the superintendent of the L. & N. and he ruled that a receiving line was to pay the cost of transfer on box and house cars that were found too high for the clearance of the line they were going to travel over, and it is being handled that way at the present time.

This discussion ended without action, Mr. Halbert stating that the question at issue had been referred to the Arbitration Committee.

RULE 3.

Interpretation No. 6

Q.—This rule permits the refusal of cars when not complying with the various requirements specified. If such cars are loaded, can they be refused, or must they be accepted and transferred at the expense of delivering line and empty car returned?

A.—Cars, whether loaded or empty, must not be offered in interchange if not equipped with an efficient hand brake, per Section A; and United States Safety Appliances or United States Safety Appliances Standard, per Section K, in good order.

Tank cars, whether loaded or empty, must comply with the requirements of Section E and P.

None of the other objections referred to would permit rejection of lading.

Mr. Fitzgerald: The interpretation states that the load must be accepted, but does not say what disposition to make of the car that violates the principles of Rule 3. Suppose we have a car offered in interchange with wooden brake beams. The rule says the car will not be accepted in interchange, but the interpretation states that we cannot reject the lading What is the disposition?

Mr. Kleist: It is entirely at the option of the receiving railroad, but if they decide to transfer the car they may do so at the expense of the delivering line.

F. W. Trapnell (Kansas City): I would like to ask where there is anything in this rule that will authorize me to give a transfer for a car with two wooden brake beams.

Mr. Fitzgerald: The interpretation plainly indicates that we do not have to take the car, but we are supposed to take the lading. We agreed in a meeting a year ago that to refuse the car in interchange was the right thing to do, and that in thirty days we would not have any question as to wooden brake beams or any of the items referred to in this rule.—that they would be taken care of by the road having

the car in its possession rather than go to the expense of transfer.

Mr. Trapnell: Rule 2 states that "A foreign bad order car previously delivered under load must be received back by the delivering line." If one road gets a car from another with wooden beams it can transfer the load and return the car, but it transfers it at his own expense. It can repair and bill the car owner, however.

Mr. Wymer: We had a case where a car was offered with a coupler other than the 6-in. by 8-in. shank type D, required under section (0). The car was built after November 1, 1920, and was transferred. We have been asked for transfer authority, which I have declined under Rule 2, which requires that loaded cars offered in interchange must be accepted, with the exceptions named in sections (a) to (e) inclusive. This is not one of the exceptions.

Furthermore, the car service rule says the delivering line shall pay the cost of transfer or rearrangement when transfer is due to defective equipment that is not safe to run according to A. R. A. interchange rules, except where the repairs can be made under load according to Rule 2. The coupler is not defective. If that car had been stenciled as built prior to November 1, 1920, it would have been perfectly safe. A stencil date is not a question of safety.

Mr. Fitzgerald: There is no question but that Rule 2 has reference to defective conditions. But there is no defect on a car equipped with wooden brake beams; it is merely a car moving contrary to the A. R. A. standards. Certain rules have been adopted for the standardization of equipment and in order to get standards certain cars are prohibited from movement in interchange. One of those items covers wooden brake beams, regardless of whether they are defective or not. I contend that such a car may be transferred and returned to the delivering line, the Arbitration Committee already having ruled that we would have to take the load. Certainly if they rule that we have the right to reject the car itself and transfer it for a condition that the delivering line is responsible for, then the delivering line should pay the cost of that transfer. We have got to interpret these rules as they are written. It is not a question of our judgment. If it is a bad rule and we live up to it for a short time it will be changed, but if we say that we are not going to apply the rule because it would not be good judgment to do so we have the rule for several years, and cars are running all over the country with wooden brake beams, for instance.

Mr. Wymer: I think we will have an interpretation on that question. It has been placed before the arbitration committee.

Mr. Armstrong: I do not know what percentage of the cars today are moving with wooden brake beams, but through the Atlanta gateway of 10 roads we had only two in the first six months of 1921.

Mr. Cheadle: This question has been talked of at every convention I have attended and the final outcome has always been that if the car is empty you can reject the car. The construction put on the rules everywhere in our district is that if the car is loaded it is handled according to Rule 2; when it is empty it is handled according to Rule 3.

Mr. Starr: I do not believe there is a man present who has a superintendent of motive power that would stand for his spending $5 to $25 to transfer a car for an owner's defect. If you get the car with wooden brake beams, you can apply the beams and bill the owner.

Mr. Fitzgerald: I move that it is the opinion of this body that Rule 3 and the interpretation in question 6, entitle receiving line to transfer a car offered in violation of the rule, and that the delivering line should assume the expense of transfer, the empty car to be returned as violating the rule.

The motion was lost.

J. E. Vittum (Columbus, Ohio): The second paragraph of Rule 4 reads:

Rule 4.

Defect cards shall not be required for any damage so slight that no repairs are required nor for raked or cornered sheathing roof boards, fascia, or bent or cornered end sills, not necessitating the shopping of the car before reloading.

We have such things as floor planks cut and side planks cut and slightly damaged by fire, and we pass them over as non-cardable defects, taking a record of them, however. They arrive at another interchange point and they are carded against us.

When the Arbitration Committee said "defects so slight that no repairs are required" and "not necessitating the shopping of the car before reloading," did they have any reference to damage by fire or cut floor planks or cut side planks? I would like a candid opinion from the chief car inspectors so that we can have an understanding on this point.

Mr. O'Donnell: In our association at Buffalo any defects to the sheathing, roof, fascia or other parts that endanger the roof or the side of the car, which may damage the lading for the present load or the next load to be put in it, we either cut the car out and repair it or put on a defect car and let it go to the point of unloading. Then we expect the road having the car to respect the rules and repair it. But unfortunately they do not. Any gondola or hopper car that is cut and boarded over, presents a cardable defect. I do not care whether the car comes back to you or not. It is not a perfect car and we are obliged to protect the owner. Any slight fire damage that does not require repairs or endanger the future service of the car should not be carded. Defect cards are not to be put on equipment for fun. Last year and two years ago we all agreed that we would stop carding slight damages, but we have got back into the old rut again. In a way I admire Mr. Shultz. He will card something in Chicago going east and we will tell him there are certain items he has overlooked. He says, "Our rule is that nothing will be given unless we personally see the car," and he stands by it.

James Reed (New York Central): Mr. O'Donnell says we are falling back into the old rut. That is not true. There are only a few railroads that are doing this unnecessary carding. Every day a bunch of defect card stubs goes over my desk from not more than four railroads out of thirty-six or forty railroads entering Chicago. It would take a basket to carry those stubs. I think that this is the place to come to some understanding, if we can. The men out on the firing line are not responsible. It is the man in charge of those men. They do not want to do this unnecessary work. It is up to us to go out to these men and tell them what we want done.

I refer to the western lines that are continuously carding defects on cars which go to their destination and come back without any repairs being made, although there is a notation on the card, "Shop when empty."

Mr. Shultz: There is no difference between a car delivered to an owner and a car passing through interchange. If cards are not required in the one case they are not in the other. It doesn't hurt to have a few sills scratched on the corners where it does no damage. You do not take out a pedestal because it happens to be chipped in the corner. Neither do you remove any car sheathing. We have considerable trouble with the car owner to keep him from plastering his own car. In fact, we have more trouble with that than the car he offers in interchange.

The settlement with private car lines is at their gateway where we have a chance to discuss it. We have less trouble with the private car lines than we have among ourselves.

There are only two conditions under which a car should be carded: If the parts are destroyed and the car is offered empty or is under load and can go to the destination.

J. A. Coleman (Cincinnati, Ohio): Mr. Vittum states that the defects are slight, but he takes a record of them. If the defect is worth taking a record of, it is bad enough to card.

In Cincinnati they handle quite a number of open top cars and we card in such a way as to facilitate the movement of the car, the defect being a cardable defect. If the floor boards or side boards are cut out, that is a cardable defect. What good is such a car at a mine? A miner will not nail a board over it. He will want to pass it on to the road handling it empty.

M. W. Halbert (St. Louis, Mo.): If I get a car in my territory with the floor boards and side boards cut out I will give the receiving line a card against the delivering line.

A. Armstrong (Atlanta, Ga.): We are handling quite a number of coal cars through the Atlanta gateway and my instruction to inspectors is in the event of one floor board cut which is properly boarded over on an empty car that the car may be moved along.

Mr. Trapnell: Such defects are carded to some extent in Kansas City; it is a matter of judgment.

W. J. Stoll (Toledo, Ohio): We card cars with the floors cut out and also cars that are damaged when the damage is on the outside of the car.

George Lynch (Cleveland, Ohio): I agree with Mr. Trapnell that it is entirely a matter of judgment. Much stress has been placed on satisfying the owner. The chief joint inspector, as I understand it, and not the car owner, is the man to say whether defect cards should or should not be issued. If the owner desires to appeal from your decision he has that right. Then the case would be decided on its merits.

We are carding when floor planks are cut through, if we know it. We do not always know it. If the fire damage is burned through the boards, sides, end or floor, we also issue the card; but if the inside of the car is scorched and burned —I do not care how badly as long as it cannot be seen from the outside or below the floor—we do not issue a defect card. I do not know that we can get anywhere on the question of all having the same opinion. We would have to change human nature in order to do that. The rule leaves this as a matter of opinion all through.

RULE 32.

Interpretations Nos. 7 and 8.

(7) Q.—If car is cornered, derailed or sideswiped, and damage is not caused by any of the five conditions named in Section (d), is it handling company's responsibility?

A.—Yes. The five conditions named in Section (d) are only some examples of irregular switching and cover cases of unfair usage other than is covered by other paragraphs of this rule.

(8) Q.—Was Item (e) intended to include the defects on car with missing coupler?

A.—No. This item only applies to defects on adjacent car caused by handling car with missing coupler.

Mr. Shultz: Under Rule 32 in the case of a car delivered to the owner of a connecting line with no evidence of unfair usage, how is it possible to determine whether this car was not in an accident with other cars which were given unfair usage? Whose obligation is it to furnish the information that that car was not so handled?

A Member: The delivering line.

Mr. Shultz: I say it is too; but if he cannot furnish it or does not furnish it, does he automatically become responsible for this damage?

President Pendleton: What action would you take in your territory?

Mr. Shultz: I ask the delivering line to furnish the information as to how the car was damaged and they reply invariably that they don't know anything about it. That still leaves it open. I know of a number of cases where a car has been ordered home with all the sills broken, and with no other evidence of unfair usage on it. This becomes a handling defect for that car, and my opinion is that the delivering line must show that the car was not damaged in unfair usage.

Mr. Stoll: We know just what the handling line has to do in case of a car being broken in two or with more than four sills broken in the car. Rule 43 will clear that up.

Mr. Halbert: That comes under Rule 43. If the delivering line cannot furnish the receiving line the information called for it will have to be responsible.

C. S. Shearman (Chicago): A car came into the stockyards with a record showing that it was the seventy-second car in the train. The train had broken in two between the fifth and sixth cars and it was claimed that there was no damage which would warrant the defect card being issued. In other words, it was stated that the car was damaged under fair usage. Yet the car has two wrecked trucks on it. Can you explain how that happened under fair usage?

President Pendleton: In that case there would be evidence enough on the car for the chief interchange inspector to make a decision under the rules.

Mr. Shultz: The case I have in mind is between two western lines where the delivering line broke a car in two. The delivering line knows nothing about it. Is the receiving line entitled to a card?

The Chair: Not under the rules. You have got a case of that kind.

Mr. Stoll: Automatically in that case if the delivering company can prove that the car was handled in fair service and broke in two they are exonerated.

Mr. Giblin: If a car is broken in two the delivering line should be able to say whether or not they broke it or how it was broken. If they cannot I believe they should be responsible.

President Pendleton: I understand a decision just rendered covers that case.

Secretary Elliott: A car arrived on one of our repair tracks with eight sills broken and in our opinion the car was a bad car. However, that is immaterial. We wrote the case up to the car owner and told him we had no record of how the damage occurred; our switching reports did not show anything at all. The owner came back and said under the rules we had to tell him how the damage occurred. We stated we didn't know and we didn't have to tell him. We sent it to the Arbitration Committee, which said we did have to tell him, and that we would have to repair the car at our own expense, which we did.

Mr. Wymer: That seems rather against all the principles of law and equity. In that way a man charged with murder is guilty until he is proved innocent.

Secretary Elliott: I think myself that the decision is unfair, because in checking cars last year we found a number of cars any of you would agree with me were really bad cars. We found in checking up with our switchmen that they did not know whether they had handled the car fairly or unfairly. If it is nothing more than breaking a coupler, if there is any chance to cover it up so that they do not have to make a damage report, they try to cover it up.

Mr. O'Donnell: Was the car delivered broken in St. Louis?

Secretary Elliott: When that car came into our yard, as far as we know, it was absolutely all right.

Mr. O'Donnell: Couldn't you as the handling line say to the owner that the car was damaged in ordinary switching?

Secretary Elliott: No, we could not.

Mr. O'Donnell: You have nothing to the contrary. Where there is a case of doubt take the safe side.

Secretary Elliott: We always thought we could, but the Arbitration Committee said we must have something to show that we did not handle the car unfairly.

H. L. Reynolds (Wabash): A car coming home from the west travelled over a trunk line, went to a switching line in Chicago and lay on their line for 30 days. When the car came home it showed signs of being wrecked; steel center sills were damaged; and there were marks of the cable where

they picked the car up. Nobody knew anything about it. It came home and we could not get a defect card for it. Should not the trunk line be responsible for the loss?

President Pendleton: Absolutely. You had the evidence there that the car had been in trouble on somebody's road.

Mr. Herring: This particular question was discussed in Montreal and, as I recall it, we agreed that the proof rested with the handling line.

RULE 33.

Interpretations 2 and 3.

(2) Q.—Are repairs to safety appliances chargeable to car owner on car derailed, cornered, sideswiped or subjected to any other Rule 32 condition where there is no other delivering line damage on the car, it being understood that damage to running boards on tank cars, due to sideswiping and cornering is never chargeable to owner?

A.—In such cases owners are responsible for the expense of repairs to running boards, except on tank cars; handholds, ladders, ladder treads, sill steps, brake shafts, uncoupling levers and parts of these items where not involved with other delivering line damage.

(3) Q.—Are the same repairs chargeable to car owner on a car not derailed but associated with another car that was derailed when the latter only developed other delivering line damage?

A.—Yes.

Mr. Trapnell: A car is derailed and you have a brake beam missing caused from the derailment. You let the car go home to the owner. Is that a cardable defect when offered in interchange?

A. Herbster (New York Central): Brake beam missing cannot be a cardable defect because you cannot run a car without brake beams.

Mr. Lynch: We have a practice at Cleveland whereby the cars are interchanged by puller service. Those trains travel from eighteen to twenty miles and brake beams are lost in transit. The car is hauled into a receiving yard where there is interchange inspection. We do not issue a defect card for the missing beam, but we try to get the delivering line, if the beam was lost on their line, to furnish a beam or their defect card. There is such a thing as cars being delivered with missing beams. But we have nothing in the rules to provide for those things and we must work out a local practice.

Mr. Trapnell: I take Rule 33 to mean that the owner is responsible for the safety appliances to his car unless there is other delivering line damage to the car making cardable defects, and I so ruled. My decision was appealed to the Arbitration Committee and this is their decision:

Q.—Are defective or missing brake beams caused by derailments cardable defects when there are no others?

A.—Your letter of September 14, above stated was considered by the arbitration committee at a recent meeting. I am instructed to advise you that defective or missing brake beams caused by derailments are cardable defects, whether or not involved with other delivering line's damage.

So you cannot put any practical interpretation upon the rules as they are written.

Eugene Head (Wabash): Is not a missing brake beam covered by Rule 3?

Mr. Adams: You cannot have an efficient hand brake if you have not a brake beam.

RULE 87.

Any company making improper repairs by using material which the repairing line should carry in stock, as prescribed in Rule 122, is solely responsible to the owners, with the exception of the cases provided for in Rule 57 and 70. Such improper repairs must be corrected within nine months after first receipt of car on home line, to justify bill.

The company making such improper repairs must place upon the car, at the time and place where the work is done, an A. R. A. defect card, which card must state the wrong repairs made, *and which will be authority for bill for both material and labor for correcting the wrong repairs.*

Interpretation.

Q.—Does the substitution of bolts for rivets in coupler yoke (in emergency cases) constitute wrong repairs for which defect card should be issued?

A.—Such substitutions are considered as temporary repairs for which no charge should be made nor defect card issued, provided the repairs are due to owner's defects. If such repairs are made in a case of delivering line defects, defect card should be issued to cover the expense of standardizing the repairs.

Mr. Jameson: That interpretation covers the case where yoke bolts are applied in place of rivets. If yoke bolts are removed and yoke bolts are applied where rivets are standard to the car will this also be considered as temporary repairs for which no charge shall be made nor defect card be issued, when these repairs are owner's defects?

R. J. Owen (Southern): That is simply perpetuating wrong repairs and I would handle it the same as if rivets had been removed. There would be no repairs.

R. J. McGrail (Chicago & Alton): There are a number of cars in the draft gear of which bolts are standard. If you apply bolts in that case you would be allowed to charge.

Mr. Jameson: That is another question. But on account of the delay to equipment many owners at outside points on their own line are putting bolts in; one of our shops may get that car and under the same circumstances may put in bolts again. The owners themselves have made those wrong repairs, and it appears to me unjust that we should not be able to make a charge in such circumstances.

Mr. Martin (Baltimore & Ohio Railroad): It seems to me that the arbitration committee answered that question. That is not wrong repairs, it is temporary repairs, and a road perpetuates temporary repairs when it puts in bolts. It has the option to put a rivet in and charge for it.

A. S. Sternberg (Belt Railway of Chicago): Even if the car came from the owner with bolts applied in place of rivets, the repairing line should not perpetuate the temporary repairs but should apply rivets and make a charge.

Mr. Jameson: We are charged by foreign lines for the application of the yoke bolts to our cars on which rivets are standard and when we take exception to that bill they claim that they are not substituting bolts for rivets but that they are simply making the repairs as per the car's standard because it carried bolts when it came to them.

President Pendleton: Perhaps some other handling line put those bolts in before he got it, but that does not make it standard to the car.

Mr. Cheadle: The A. R. A. standard is a 1¼-in. yoke rivet. Unless there is a question of transom draft gear, it makes no difference whose car it is, bolts are wrong.

[The remainder of the proceedings, largely a discussion of Rule 101 and the prices in Rule 107, will appear in the next issue.—EDITOR.]

Cost of Repairs in Railroad and Contract Shops

In testifying before the Interstate Commerce Commission at the time of the inquiry into the railroad rate situation, S. M. Felton, president of the Chicago Great Western gave comparisons of the cost of work in railroad and contract shop.

Mr. Felton said that his road had saved a considerable amount of money owing to the difference in labor costs through the repair of cars in outside shops. Work which the Chicago Great Western estimated would cost $1,100 per car, cost only $800 under contract while the cost of repairing five locomotives which that company has sent to outside shops was about 30 per cent less than what the same work would have cost in the company shops.

He told of having steel freight cars repaired in this manner and said the work was done for about one-third less than it would have cost had his road had the facilities to perform the work. A large part of the equipment which that road had repaired outside, Mr. Felton said, was equipment which had been roaming around the country during the period of federal control under the general plan of pooling equipment.

Free Life Insurance on D. & H.

L. F. Loree, president of the Delaware & Hudson Company, in a circular to employees dated January 1, announces a contract between the D. & H. and the Metropolitan Life Insurance Company, of New York, under which all employees who have been in the service of the road two years or more and who make application on prescribed forms, may have free life insurance to the extent of $500; and may take, at very low rates, additional insurance, up to an amount equal to their respective annual salaries (but not over $5,000).

Advantages of a Manufacturing Tool Room*

Discussion of the Importance of Manufacturing Tool Rooms in Modern Railroad Shops; Several Efficient Jigs

By J. H. Painter
Shop Superintendent, Atlantic Coast Line, Rocky Mount, N. C.

MANUFACTURING tool departments should be located as nearly central as possible on railroads operating 1,000 miles or more, all special tools or jigs being made at this one shop, from sketches furnished to the mechanical engineer, who in turn makes blue prints so that all parts will be standard. We have all advanced in knowledge since the tool room of some years ago which was located as a rule in the machine shop with a leading man in charge, supervised by the machine shop foreman. The latter was then, as now, shouldered with many new problems each day so that often he could not give much time or attention to the operation of the tool room. Many suggestions offered and submitted to the leading man, therefore, were worked out according to a somewhat limited experience.

The manufacturing tool room of today is a separate department in charge of a capable man who devotes his entire time to it. All serviceable tools are kept in the different distributing tool rooms, located conveniently to the machine, erecting and boiler shops in the locomotive department, and the planing mill and steel car shops in the car department. All tools such as air motors, air hammers, air hose and all other tools are returned to the distributing tool rooms in the different departments. If any repairs are needed the employee returning the defective tool is furnished with a serviceable one, which presents delay. The tools accumulating in the different distributing tool rooms are sent to the manufacturing tool room each afternoon, and all repairs are made in that department for the reason that there both repair parts and competent, experienced repair men are available. A large saving, both in material and labor, is effected by having a place for everything in the tool room and keeping everything in its proper place.

Tool Room Equipment

The following equipment is recommended for a manufacturing tool room: one 18-in. engine lathe; one 16-in. engine lathe with backing-off attachment; one 14-in. engine lathe; two universal milling machines, small and large, with all attachments; three die grinders; two universal tool grinders; one surface grinder with magnetic chuck; two drill grinders; one 24-in. radial drill press; two sensitive drill presses; one stock cut-off machine; two emery wheel stands, large and small; one tool cabinet, and two electric furnaces with quenching baths.

Often we have blamed the tool dresser or hardener for a reamer or tap that was warped, when, if the matter was carefully traced back to the steel before it was cut off from the bar, it was found that the tool hardener was not to blame. Many other causes can be attributed to a warped tool. The modern tool maker realizes that a piece of steel must be straight and centered true before putting it in the lathe for turning. If 1/32 in. more of metal is turned off from one side of the bar than the other, the reamer or tap will be warped no matter how careful the tool hardener may be. The system of equalizing the steel by heating to a low red and dipping in warm oil after the red has disappeared will prevent the steel from cracking and springing when being hardened. This process also removes all hard spots from the steel.

More attention is given to the making of accurate duplicate parts in the manufacturing tool room than in other departments for the reason that the tools are often used later by inexperienced men who cannot be depended on for accurate work otherwise.

Chuck for Making Front End Main Rod Keys

A special chuck, illustrated in Fig. 1, was developed at the Rocky Mount tool room for making front end main rod keys on turret lathes and we have found this method to provide a considerable saving in machining these keys. Two of the chuck jaws *AA* are made 5/16 in. off center and

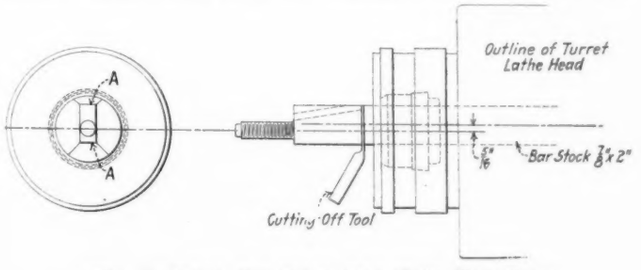


Fig. 1—Chuck for Front End Main Rod Keys

*From a paper presented before the Southern and Southwestern Railway Club.

hold the bar of iron in position so the adjusting screw on the end can be turned and threaded as shown. The cutting-off tool is then brought into play and the key subsequently given the required taper.

Machining Tank Valve Bodies

Before using the tool, shown in Fig. 2, tank valve bodies were chucked in a lathe, bored and seated by a machinist or apprentice, thus making a lengthy, expensive operation. Considerable time is saved by the tool illustrated which consists of a bar of machine steel turned to a No. 5 Morse taper

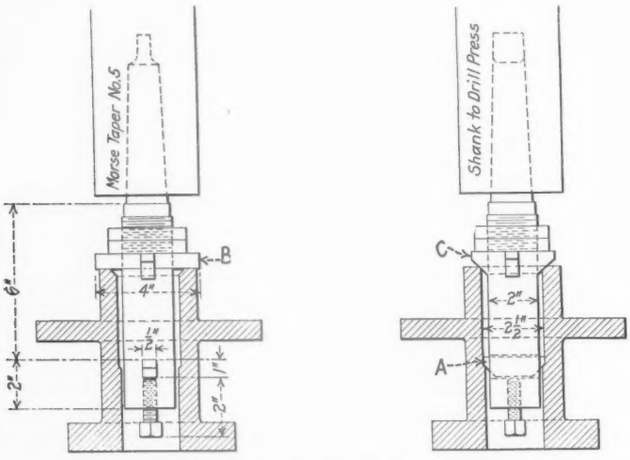


Fig. 2—Tool for Machining Tank Valve Bodies

on one end for insertion in the drill press spindle. The other end is slotted at three different points to receive double-acting cutters, *A*, *B* and *C*, arranged to bore, face and seat the tank valve respectively in one operation. We machine about five valves on the drill press to one on the engine lathe. The operation is performed by a special drill press man, no lathe chucking, setting up or similar operations being required. The bar is made of machine steel and all cutters of high speed steel. Brake cams are machined in the same way.

Making Wheel Lathe Forming Tools

Before the method of machining wheel lathe forming tools illustrated in Fig. 3, was installed in the manufacturing tool room, all forming tools were shaped to size, thus causing the labor cost to run very high. Several chucks have been made for this work but holding only one tool. By holding four tools we effect a considerable saving in the cost of the work.

The forming tools in the rough are drilled with a one-inch hole at the flange end, thus leaving less metal to be removed by the milling cutters. The latter are made in two separate pieces and of the same contour as called for by the M. C. B.

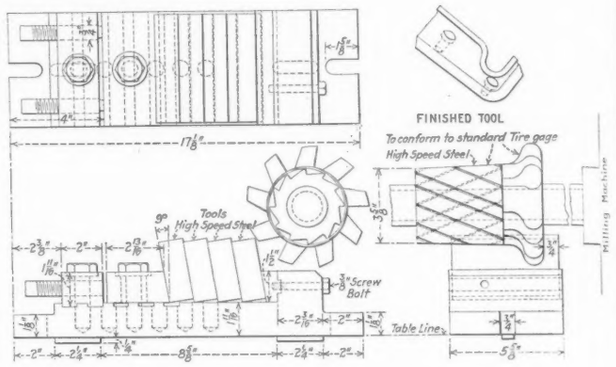


Fig. 3—Wheel Lathe Forming Tool Chuck

rules, having a taper of 1 in. in 20 in. This allows the tools to fit square in the chuck while the cutter makes the required taper. The teeth are spaced quite far apart in the cutter in order to allow ample clearance for the chips. Two cutters are used to make forming tools, one standard for trailer and driving wheel tires, and another for tender truck and switch engine tires. It became necessary to have two tools when the flange of tender and switch engine tires was changed from 1⅛ in. to 1 in. high. This method of making forming tools saves approximately 65 per cent over former methods.

Ripping Flue Expander Segments

A fixture, shown in Fig. 4, was designed to hold flue expanders so that they can be cut in segments without leaving any burrs. By the use of the fixture the saw cuts each piece clear through and no pieces are left to be ground or filed. When removed from the fixture each piece stands alone, and all pieces are interchangeable. Referring to Fig. 4, the body *A* is made of steel tubing, *B* being a plug welded in one end. *C* is a plug which follows the expanders and is provided with a key which slides in the end of the barrel, thus causing the slots in the plug to always come in line

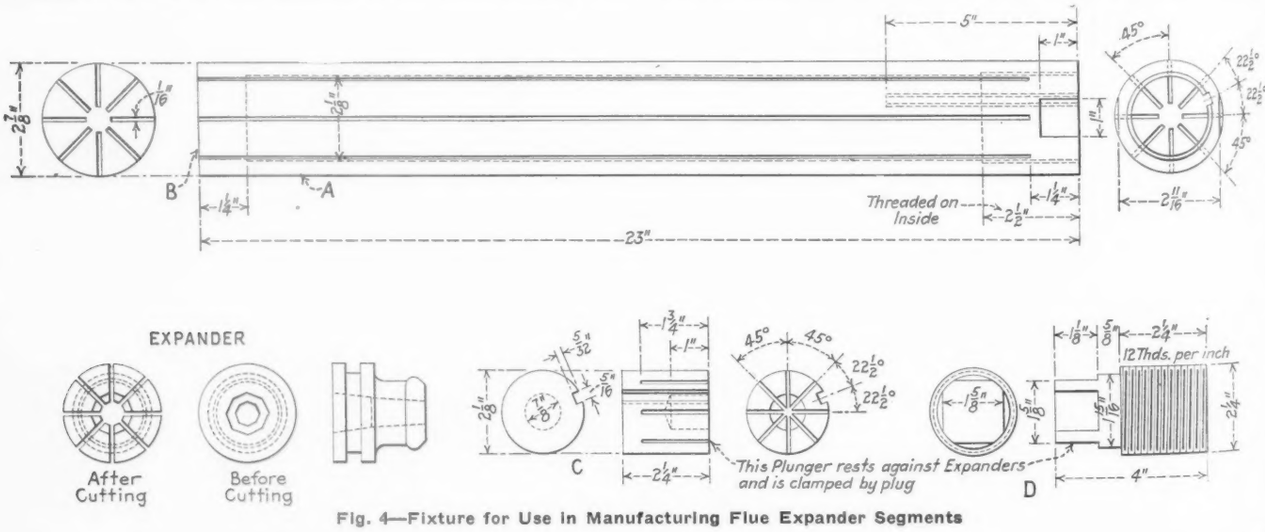


Fig. 4—Fixture for Use in Manufacturing Flue Expander Segments

with the slots in the body of the jig. *D* is a plug or long nut which screws in the end and holds the expanders tight.

In cutting the expanders we drop eight (or more accord-

ing to the length of body *A*) in the barrel; *C* follows. The nut or plug *D* is then tightened down and the dog or driver placed on the square end of the nut. The index head, or miller, is set so it will follow in each slot; then the milling is done. The slots in the fixture are milled 1/64 in. larger than the segments are to be cut. By using a triple head and three fixtures we can mill 36 expanders at one setting, making body *A* long enough to hold 12 instead of eight. The same feed is used with three cutters, as the machine can drive them with ease. By using this fixture we save on one operation alone five segments out of eight; that is, we can rip eight with this jig as quickly as we could rip three with the old mandrel. Another advantage is that when the eight segments are finished they are all separate segments. On the old style mandrel there are three to break apart, then grind or file.

Jig Used in Milling Taps and Reamers

A special jig, Fig. 5, was designed so that three spiral reamers can be milled at the same time. The angle plate *1* is made of cast iron; the spindles or centers are made of 2¼ in. tool steel hardened and drawn. The inside center remains stationary, while the other two can be moved in and out. The three head centers are all movable. The object in

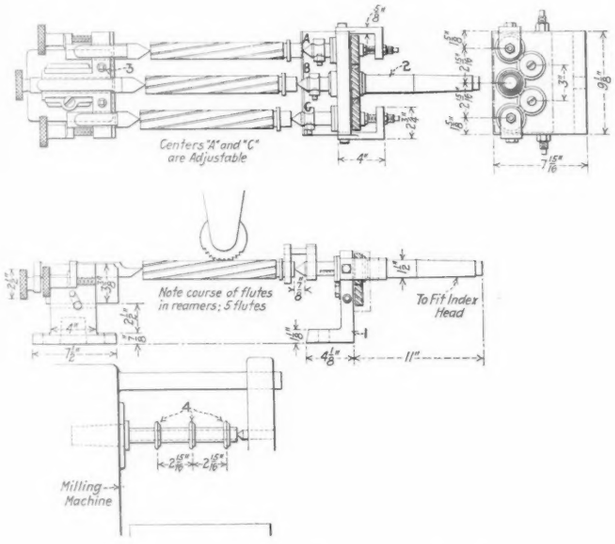


Fig. 5—Tap and Reamer Milling Jig

having the spindles or centers move in or out is to make each of the three milling cutters stop at the head of the reamers when milling spiral flutes. The spindles and centers can be adjusted so that any ordinary spiral can be cut on a reamer. The center spindle *2* is placed in the socket of the index head and is geared to the other two, so that all three will rotate in the same direction. The dead centers are placed in a single stand, two set screws *3*, being used to lock the three dead centers. The gears are cut spiral, thus overcoming practically all lost motion. The two back live spindles are graduated so that when reamers are milled to eight degrees or any other spiral, the spindle can be set before the reamers are placed in the jig so that the cutters will reach the end of the flute at the same time.

When the jig is ready for operation the index head turns and the reamers turn with it, just as if all was solid. The milling cutters are shown at *4*, spaced with blocks, each cutter being of the same size. Practically all frame reamers are made with five and six flutes, eight degrees spiral. When using this jig we always use the same speed and feed, just as though we were using one cutter. The labor cost is reduced about 60 per cent.

Adjustable Mandrel for Turning Eccentric Cams

Although practically no new locomotives are now equipped with the Stephenson valve gear, there are many of these old gears still in service and an adjustable mandrel of value in turning the cams is shown in Fig. 6. The job is preferably done on a boring mill, but can be performed on a lathe. The base *A* of the fixture is clamped firmly in a central position on the table or face plate of the machine. The graduation plate *B* shows six different throws and answers for all common Stephenson valve gears. We use only two mandrels,

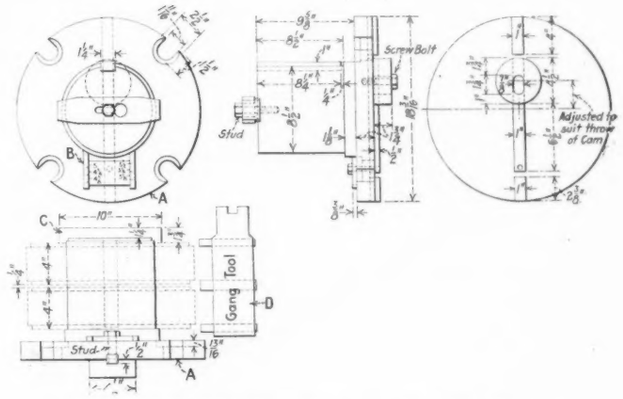


Fig. 6—Adjustable Eccentric Cam Turning Mandrel

16½ in. and 15½ in. The top clamp *C* is made so that one turn of the cap bolt releases the clamp. The clamp is then slid over and lifted off.

In using the mandrel each throw can be easily obtained without removing the mandrel from the machine bed. Two eccentrics are machined at the same time, ¼ in. space being allowed between them. They are provided with a keyway before turning and fit over a key in the mandrel. After being

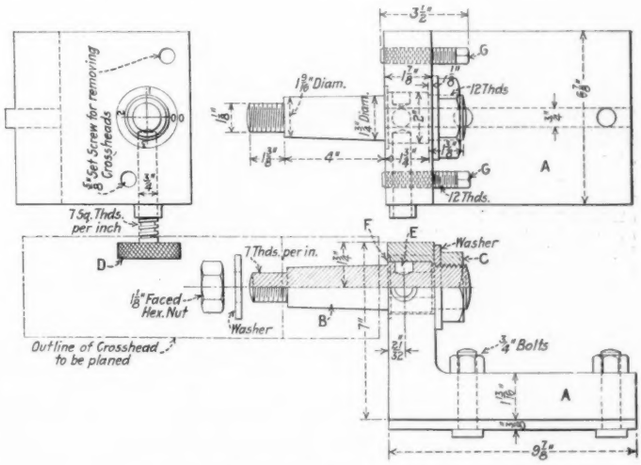


Fig. 7—Jig for Use in Planing Valve Stem Crossheads

turned on the outside, the gang tool *D* is used and both cams are finished at the same time for the lips on the eccentric straps. By using this mandrel we save the cost of laying the blocks off in order to secure the proper throw. The mandrel does this and holds the blocks rigidly and allows a much heavier cut to be obtained and therefore the time saved by its use is considerable.

Jig for Planing Valve Stem Crossheads

For machining valve stem crossheads from the rough, or after metal has been applied, the jig, shown in Fig. 7, has been developed. The objects of using the jig are first, to

reduce the time consumed in the operation; second, to produce more accurate machining, and third, to cause the operator to be more interested in the work, due to the fact that the crosshead is set up only one time.

In applying the jig to the planer table, *A* represents the base of the jig which is placed on the planer or shaper, being held in alinement by the tongue which fits in a slot in the table. Two bolts and nuts fasten the jig securely in place. The crosshead is applied to spindle *B*, being held in position by the nut and washer shown. After one side of the crosshead has been machined the nut *C* is loosened, also screw *D*, thus allowing spindle *B* to revolve freely. The crosshead is given one quarter of a turn, screw *D* tightened and locked in hole *E*. Nut *C* is then tightened when the second side can be planed. The other sides are planed in the same way. The spindle *B* has four holes into which screw *D* threads tightly as each comes around. This makes practically an index head with four positions 90 deg. apart. When the crosshead is ready to be removed the two screws *G* are tightened, thus causing the crosshead to be removed without a blow from a hammer. By using the two screws the spindle can always be kept in excellent condition.

Since using this jig we have reduced the operation of planing a valve crosshead 75 per cent as determined by actual time studies, counting the time from floor to floor. The base of the jig is made of cast iron, the spindle of 2½ in. high carbon steel, hardened and drawn. *F* is a bushing in the cast iron base. The spindle is ground in so there will be no lost motion. The construction is such as to insure accurate work, prevent the loss of time in using surface gages, and increase production.

Grain vs. Flesh Side for Leather Belts

DURING the latter part of the past summer, tests of the capacity of the grain and flesh sides of leather belts were begun in the research laboratory at Cornell University under the direction of R. F. Jones, director of the laboratory. Covering a period of more than two months, continuous tests were run on the testing apparatus belonging to the Leather Belting Exchange, which is being operated under the supervision of the university, using five 4-in. single belts, 30 ft. long, of different manufacture. They weighed from 16 to 18 ounces per sq. ft. Every effort was made throughout the tests to standardize conditions and to reduce the probable error to a minimum; all this unquestionably was accomplished. All five belts were run long enough previous to the experiments to have been thoroughly "run-in," and had reached a condition of constant capacity when the records were taken.

The method of procedure was to take horsepower readings from the belts first when running on the grain sides, and then when running on the flesh, the power being gradually increased until about 4 per cent slip had been reached.

In considering the results, it must be remembered that a leather belt is at its lowest point of capacity when new, largely because of the elasticity of the leather and the newness of its surface. Leather belts are well stretched in the process of manufacture, so that when the belt is put on the pulley there may be as little stretch as possible consistent with thorough lubrication and retaining the natural life or elasticity, which is such a valuable property of the leather belt. When a new leather belt is placed on the pulleys, however tightly, it will elongate under load. But after the tension of the load has been removed it returns very nearly to its original length. This stretch is an annoyance when installing a new belt, but it is of the nature of a safety valve, protecting both belt and machinery.

To review the details of each individual test would require more space than is here available. Suffice it to say that a summary of all of the results is clearly in favor of the grain side from the standpoint of power transmission. In fact, it may be concluded from it that under reasonable shop tension, the flesh side will average only 50 to 60 per cent as much horsepower as the grain side. At higher tensions the flesh side will do better, averaging from 50 to 100 per cent as much power as the grain, depending upon the belt, the tension and the conditions of service.

A curve plotted from the readings taken when the belts were running on the flesh side is similar both in shape and capacity to that given by many of the leather belt substitutes. All that can be said of the test belts run on the flesh side is

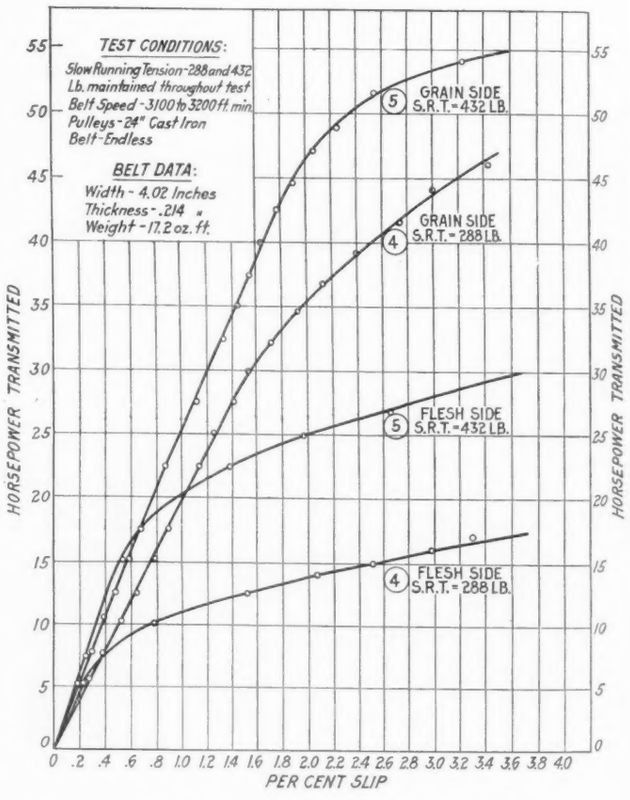

TEST CONDITIONS:
Slow Running Tension-288 and 432 Lb. maintained throughout test
Belt Speed-3100 to 3200 ft. min.
Pulleys-24" Cast Iron
Belt-Endless
BELT DATA:
Width-4.02 Inches
Thickness-.214 "
Weight-17.2 oz. ft.
5 GRAIN SIDE S.R.T.-432 LB.
4 GRAIN SIDE S.R.T.-288 LB.
5 FLESH SIDE S.R.T.-432 LB.
4 FLESH SIDE S.R.T.-288 LB.
HORSEPOWER TRANSMITTED
PER CENT SLIP
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
0 5 10 15 20 25 30 35 40 45 50 55

Chart Showing Results of Belt Tests

that the data obtained from them were more uniform than that taken when they were running with the grain side in contact with the pulley.

Using the horsepower transmitted and the percentage of slippage as the co-ordinates, on Chart PT 57, which is representative, the grain tests showed an almost curveless gain in horsepower up to 53, when the slip reached about 3 per cent for belts running at a slow running tension of 432 lb. In the case of the test belts operated at a slow running tension of 288 lb., the 3 per cent slippage was reached at about 44 h.p. With the belts running on the flesh side, however, the 3 per cent slippage mark was reached at 28 h.p. when operated at a slow running tension of 432 lb., and at 16 h.p. when the tension was 288 lb.

In short, the evidence produced from the mass of data obtained leaves no reasonable doubt but that there are distinct advantages in power transmission to be had from running leather belts on the grain side. It is simply another case where scientifically obtained evidence must outweigh arbitrary opinions held usually by reason of personal and, oftentimes, inaccurate observation.

High Power Surface Grinder a Useful Shop Tool

Description of Typical Machine Operations Economically Performed on Blanchard Vertical Type Grinder

THE grinding machine in its early stages was for the most part a low power tool, used exclusively for finishing operations. As the grinder demonstrated its value, however, and came into more general use, there was a gradual development until at the present time grinding machines are available of sufficient power to finish castings and forgings from rough stock in one operation with a considerable saving in time, reduced labor cost and increased accuracy of work.

Several different types of production grinding machines

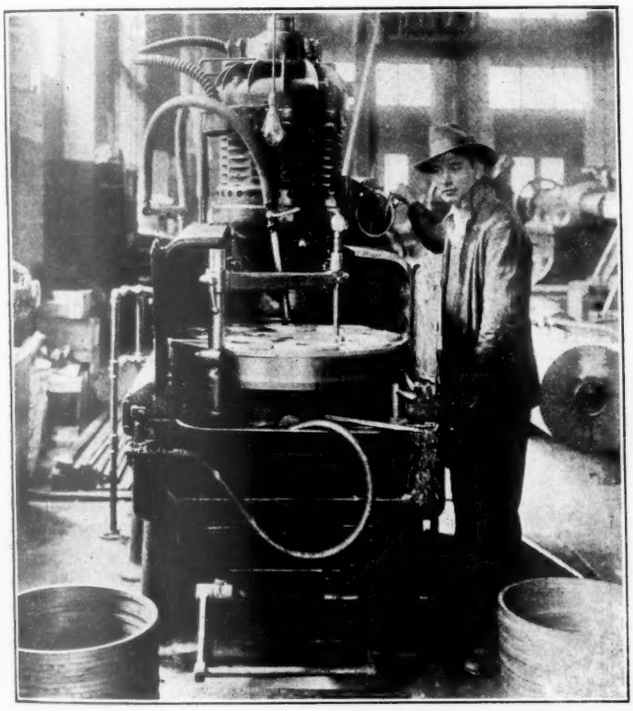


Fig. 1—Blanchard Direct Motor Driven Grinder Finishing Crank Pin Collars

have been developed and are now being used in railroad shops with extremely satisfactory results. Among these may be mentioned the high power vertical surface grinding machine with rotating work table, made by the Blanchard Machine Company, Cambridge, Mass. Typical operations, economically performed on this machine, are described in the following article, and include grinding such locomotive parts as cylinder packing, slide valves, balance plates and steam chest covers, valve strips, rod washers, rod keys, crosshead keys, grease cellars, small links and link blocks, and hammer die blocks within the capacity of the machine. These are but a few examples of many parts which could be mentioned.

Although Blanchard grinders with belt drive can be furnished if desired, the No. 16 direct motor-driven machine, illustrated in Fig. 1, is recommended as being the most efficient and desirable to install for general railroad machine shop work. The production of this machine is greatly augmented by the rotating table which is made in the form of a magnetic chuck and grips the work by the turn of a switch, thus practically eliminating the time required to set up work. The chuck is 30 in. in diameter and work up to 12 in. high can be ground on the belted machine, or 14 in. high on the direct motor driven machine. A continuous reading caliper attachment graduated in thousandths, is provided for rapidly and accurately measuring thickness. This is shown in the illustration.

Crank Pin Washers and Cylinder Packing

The crank pin washers shown on the machine in Fig. 1, are made of steel of approximately 7¾ in. outside diameter, 2½ in. inside diameter and ½ in. thick. They are received either rough forged or rough machined and ground on both sides, approximately 1/32 in. of stock being removed from either side to a limit of plus or minus .01 in. Seventy-five washers can be ground per hour. Should some practical shop man question the need for an accuracy of .01 in. on a crank pin washer, suffice it to say that much greater accuracy could be obtained if necessary with no increase in time or effort.

The essential advantage of grinding packing rings is that both sides can be held parallel and to size within extremely close limits. While greater accuracy can be secured on the grinding machine, it is doubtful if a limit of more than plus or minus .003 in. would be justifiable or necessary. Another advantage in grinding packing rings is that a coarse feed may be used in cutting the rings from the packing pot on the boring mill, thereby reducing the machining time for this operation. It may be argued that there is no advantage in grinding the sides of packing rings to close limits when the grooves in which the rings fit are not machined so accurately. The reply to this is that if piston ring grooves are machined as accurately as possible with modern equipment and packing rings are kept to within close limits of accuracy, the best fitting ring which it is possible to obtain under the conditions will be assured, the life of the rings will be increased and steam leaks reduced.

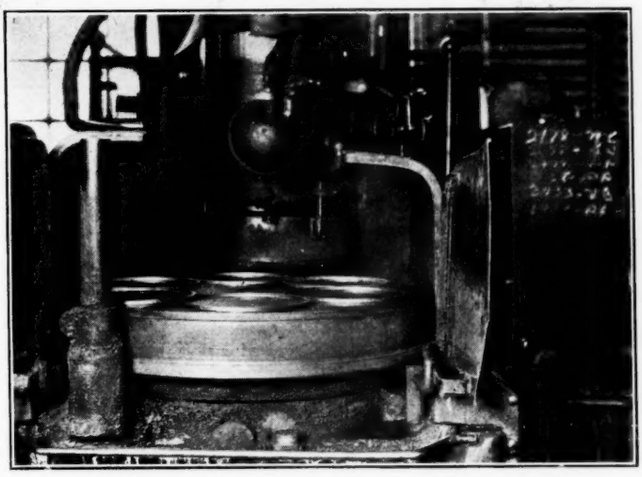


Fig. 2—Finishing Air Compressor Packing Rings

All sizes of packing rings in common use can be ground. Those shown in Fig 2 are air compressor packing rings approximately 9½ in. in diameter. When cylinder packing rings are ground, the records show that a 24 in. ring can be ground on two sides, removing approximately .01 in. per

side and to a limit of plus or minus .003 in., 20 rings being ground per hour.

Truing Slide Valves

Slide valves are ground, as illustrated in Fig. 3, and can be finished in one setting without subsequent hand work. Previously, new valves were either milled or planed and then scraped to a good bearing. As the scraping was a hand operation, it consumed considerable time but by grinding, scraping is entirely eliminated and the grinding time is considerably less than would be required to mill or plane the surfaces. The two valves shown in the illustration are made of cast-iron of approximately 19 in. by 8½ in. by 4½ in. over all dimensions. These valves are ground from the rough on two sides with 3/16 in. of stock removed from each side, the limit of accuracy being plus or minus .006 in. Six valves can be ground per hour.

As with other grinding operations this one possesses a particular advantage in the case of worn slide valves with glazed and extremely hard surfaces. These surfaces are too hard to be scraped without preliminary machining but are ground true rapidly, economically and with the removal of a minimum amount of metal. Had there been only one valve to grind it would have been placed in the center of the chuck

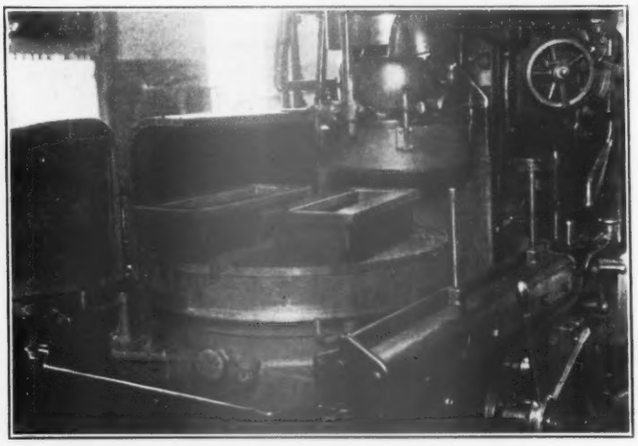


Fig. 3—Worn Slide Valves Are Trued by Grinding

and a higher chuck speed used, reducing the time proportionately.

Grinding Driving Box Grease Cellars

Driving box grease cellars are usually made of cast-iron and on account of the thin sections the castings oftentimes are so hard that it is difficult to machine them. They are also comparatively weak structurally and if subjected to undue clamping strain are liable to crack. From a consideration of the above facts it is evident that the machining of driving box cellars is an operation particularly adapted to being performed on a grinding machine equipped with a magnetic chuck. Cast-iron driving box cellars 10 in. by 8 in. by 6 in. in size are received in the rough, two sides only being ground (the ones which make the fit in the driving box). One-eighth inch of stock is removed from each side of the box, the limits of accuracy being plus or minus .01 in. Fifteen cellars can be ground per hour.

An incidental advantage of grinding driving box cellars or other castings from the rough is that patterns can be trimmed closer since the grinder does not need to go below the hard surface of the casting. All that is necessary is to clean up the surface. Forgings for rod keys and other small parts can also be made much closer to size with the single requirement that there be enough metal to clean up the surfaces to finished size.

Segmental Retaining Rings

When work is held magnetically, setting up time is practically eliminated and it is easy to change from one job to another. For example, after grinding main valves or steam chest covers, the machine can be used immediately without further adjustment, save lowering the grinding wheel spindle, for grinding a set of retaining ring segments. A group of eight of these segments is shown on the grinding

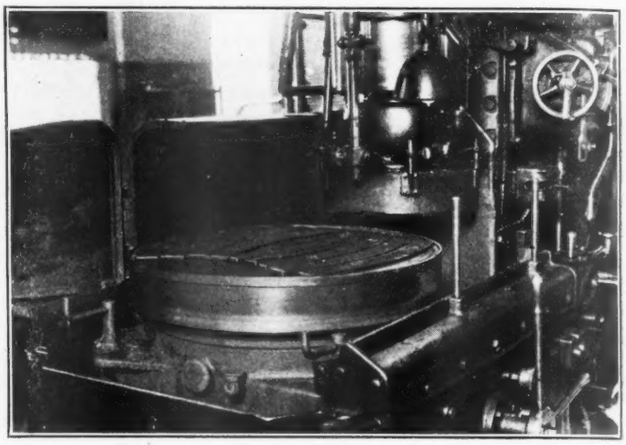


Fig. 4—Magnetic Chuck Facilitates Holding Retaining Ring Segments

machine table in Fig. 4 ready for grinding. They are approximately 21 in. by 2½ in. by ⅜ in.,, being received rough from the blacksmith shop, where they are bent to the required arc to fit the driving wheel center with which they are used. Both sides of the segments are ground, approximately 1/16 in. of metal being removed from each side, or enough to clean up the surfaces. About 27 segments can be

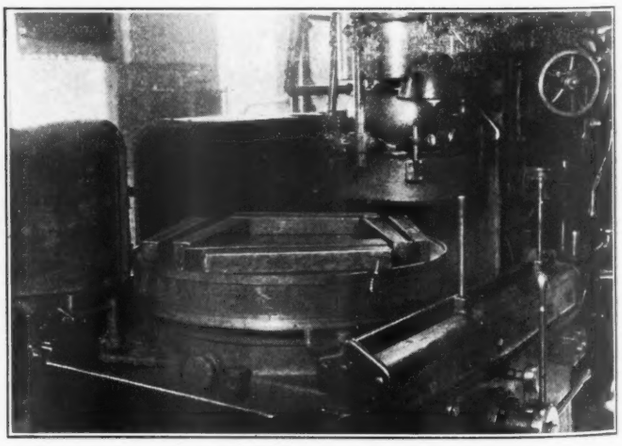


Fig. 5—Main Rod Keys Being Dressed for Further Use

ground per hour depending upon their size and the number that can be placed on the chuck of the grinding machine.

Miscellaneous Grinding

Main rod keys can be forged or roughed out from bar stock with heavy feeds and finished on the grinding machine. These keys are made in many different sizes, being ground on two sides and approximately 1/16 in. of metal removed from each side. An allowance of plus or minus .01 in. is adhered to for this work and while this limit may seem unnecessarily close it can be obtained without slowing down the production of the machine and will result in better fitting keys. With 12-in. keys 1¼ in. thick, and having a taper

of 2½ in. to 1¼ in., 36 keys can be ground per hour. With 10-in. keys, ½ in. thick and having a taper of 3 in. to 2¼ in., the production is 30 per hour. Worn main rod keys can also be dressed as shown in Fig. 5 and made ready for use again. For this latter work the rapid set up and quick removal of just enough metal to clean up the surfaces is a most important advantage.

Owing to the extended foot on the Walschaert link, it would usually be too long to be held on the table of the Blanchard grinder but the smaller Stephenson links and link blocks can be ground effectively on this machine. Stephenson links, 24 in. by 8 in. by 3 in. thick, are ground on two sides, approximately ⅛ in. being removed from each side to the limit of .006 in. Six links can be ground per hour.

Pedestal braces, made of cast-steel, 18 in. by 7½ in. by 7½ in. are ground on two sides, ⅛ in. stock being removed per side with three braces placed on the magnetic chuck at one time. Twenty minutes floor to floor is the time required for grinding. Another important use of the Blanchard as well as other types of grinders is due to the present tendency to electrically weld many broken parts and build up worn places with electric welding. Tools and cutters, subsequently used to finish these built-up places to size, often will not stand up under the hard usage but with the grinding machine, welded surfaces are finished quickly and smoothly to the exact dimensions required.

An Investigation of the Art of Milling*

Conclusions Drawn from an Investigation of Milling Cutter Action Carried Out at the University of Michigan

THE practice of milling has, during the present century and the last decade of the nineteenth century, encroached decidedly on the field occupied by the shaper and planer. The action of milling possesses advantages over shaping; it also has its drawbacks. Much work must be done before we can state the relative merits or potentialities.

In the art of milling, the only published investigations have been handled by machine-tool builders. Attention has

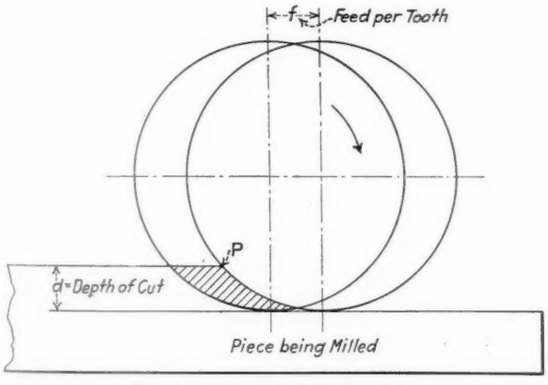


Fig. 1—Shape of Milling Chip

in consequence been focused more on the machine than on the cutter. Further, in the investigations already made, the objects sought have usually had the defect of being too immediate. This paper describes an attempt to investigate the fundamental principles underlying the action of milling.

It is shown in the present investigation that metal is removed more efficiently with thick chips than with thin chips. It follows from this that, other conditions being equal, including speed and feed per minute, the cutter with the fewest teeth gives the greatest efficiency. However, it is evident that the efficiencies of two cutters with different numbers of teeth are equal provided the table feeds be adjusted so that the same feed per tooth is effected. This gives a definite working theory on the influence of spacing.

In addition to the present investigation, experiments published in substantiation of the advantage of wide spacing agree in confirming this theory. It is definitely established that for a given material, tooth shape and sharpness, thickness of chip is the sole criterion of the efficiency with which metal is removed in milling and that increase of spacing over that required for free cutting is a handicap. Present-day high-powered cutters have several times the chip space needed. Limitation of machine power has doubtless been the chief factor in giving false bias to the influence of spacing.

A Dynamical Study of Single-Tooth Action

The chip taken by a plain slab mill is very different from the chip taken by a lathe or shaper tool. A milling chip is shown exaggerated in the shaded portion of Fig. 1. The two circles show the outline of the cutter at the beginning and at the end of the interval taken for the cutter to revolve through the angle subtended by one tooth. The shaded portion will therefore represent the material removed by one tooth and will have an area $f \times d$.

The chip starts infinitely thin and its thickness gradually

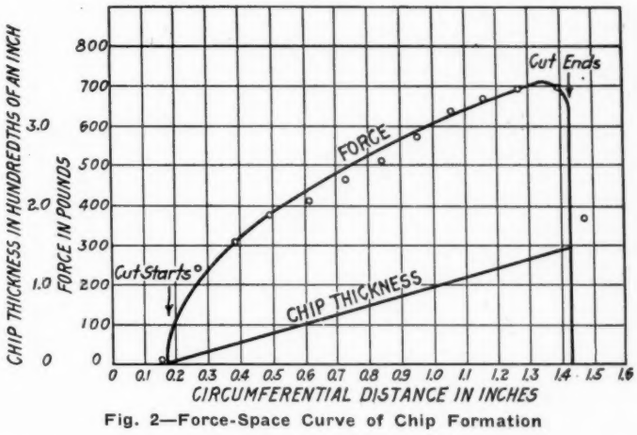


Fig. 2—Force-Space Curve of Chip Formation

increases to a maximum just before the finish, from which point it quickly decreases. This decrease is practically instantaneous in an unexaggerated chip. The question arises, how does the force vary throughout the cutting of this chip?

The first problem is to find how the tangential force varies in relation to chip thickness. For measuring this force while the chip is being formed under reasonable commercial velocity conditions, a dynamical measuring method is the only solution, as a chip is completely cut in about one-tenth of a second.

An example of a chip study made with a special chip in-

*Abstract of a paper presented by John Airey, professor of engineering mechanics, University of Michigan, and Carl J. Oxford, chief engineer, National Twist Drill & Tool Company, Detroit, Mich., at the December, 1921, annual meeting of the American Society of Mechanical Engineers.

vestigator is given in Fig. 2, where it is very clearly shown that the force employed is not proportional to the chip thickness. In other words, material is removed more efficiently as the chip becomes thicker. This is confirmed later by experiments on varying feeds and furnishes the true explanation of the supposed advantages of coarse-tooth cutters.

Over twelve hundred chips were cut and the energy computed. These were taken at three different cutting speeds, viz., 17.5, 32 and 44 ft. per min., respectively. The average of the energy required at different speeds was remarkably equal. If the energy used at lowest speed be taken at 100, the results are:

Speed in ft. per min.	17.5	32	44
Energy	100	101.8	97.4

As there appears to be no law in this and the variation is slight, presumably due to experimental error, the conclusion was reached that speed does not influence energy required.

Influence of Rake and Feed. The results of the analysis of sixteen sets of chip formations each in cast iron, bronze, machine steel and carbon tool steel are given in the following table. The consistently superior economy of heavy feed is observed. Taking the 0-deg. rake tool as 100, we have:

	Cast Iron	Bronze	Machine Steel	Carbon Tool Steel
Production of 0-deg. rake tool =	100	100	100	100
Production of 10-deg. rake tool =	133	113.2	118.7	106
Production of 20-deg. rake tool =	138.4	123	157.2	112.2
Production of 30-deg. rake tool =	142.1	118	172	112

Effect of Lubrication. Various experiments were run with lubricants. The results must be taken qualitatively rather than quantitatively. This topic offers an important field of investigation for future experiments.

In milling there is a decided influence entirely apart from heat-conducting properties. If the surface exposed by the last chip was very slightly smeared with an oiled finger (the oil film was scarcely discernible), the energy consumed in taking the next chip was from 10 to 25 percent lower in nearly all cases.

TABLE 1 EFFECT OF LUBRICATION

Milling Cutter: Clearance angle, 5 deg.; rake angle, 10 deg.; spiral angle, 0 deg.; diameter, 6 in.; number of teeth, 34; depth of cut, 0.3 in.; width of cut, 0.5 in. Material: Alloy steel No. 10.

Exp. No.	Feed in. per min.	Speed r.p.m.	Vol. per Tooth cu. in.	Torque in-lb.	Cu. in. per hp-min.
1026 Oil	0.92	27.9	0.000145	306	1.018
1026 Dry	0.92	27.9	0.000145	364	0.855
1027 Oil	2.36	27.9	0.000375	760	1.070
1027 Dry	2.36	27.9	0.000375	875	0.930
1028 Oil	3.10	19.3	0.000710	1335	1.148
1028 Dry	3.10	19.3	0.000710	1430	1.071

The results of six experiments, which merely touched the fringe of the effect of lubrication, are given in Table 1. It is dangerous to generalize too broadly from a few results, but one can at least conclude that lubrication effects a reduction of energy and that this reduction appears more pronounced in light cuts. It should be again noticed that this is almost pure lubricating action and that the conduction of heat by the oil plays only an insignificant part.

Effect of Spiral. A 34-tooth non-spiral cutter 6 in. in diameter and having a 10-deg. rake was run in comparison with cutters similar in all respects excepting that they possessed a 12½-deg. spiral angle. Two cutters with left- and right-hand spirals, respectively, were used in combination, thus eliminating end thrust. Two different combinations of speeds and feeds were used. The material cut was machine steel. The results were as follows:

R.p.m.	Feed, in. per min.	Cu. in per hp-min. 0-deg. spiral	Cu. in per hp-min. 12½-deg. spiral	Lost output of spiral cutter
28.1	0.92	0.422	0.338	20 per cent
16.1	0.92	0.568	0.458	19.4 per cent

The authors are well aware that a general belief exists in the superior power efficiency of spiral cutters. Frequent statements to this effect can be found in the literature of the subject. In this investigation it has been impossible to substantiate these. It is difficult to understand the growth of the belief that spiral cutters are more efficient, because abstract analysis leads to the conclusion that spiral cutters must be inferior to straight cutters. By "inferior" the meaning intended is in reference to power efficiency only. The use of a spiral angle is heartily recommended, for it results in continuity of action, tends to avoid chatter, and keeps the driving power more smoothly constant. The smallest angle consistent with smoothness of action should be used.

Theory of Tooth Spacing. Opinions differ on the influence of tooth spacing or, in other words, the relative merits of coarse-tooth compared with fine-tooth cutters. Many cutter manufacturers standardize two types, the fine-tooth cutter and the "high-powered" cutter. Experiments have been published purporting to show the advantage of coarse-tooth cutters. Possibly many others have been made and have probably convinced the experimenter that the claims made were justified.

There is an interesting delusion in this subject and it is unfortunate that it has held sway for so long, for it has resulted in inefficient types of cutters being used. Most of the so-called high-powered cutters today on the market would be improved if more teeth were given.

It has been demonstrated earlier that the force required to remove metal does not increase in proportion to the chip thickness. It follows directly from this that as feed is increased the force will not increase in proportion.

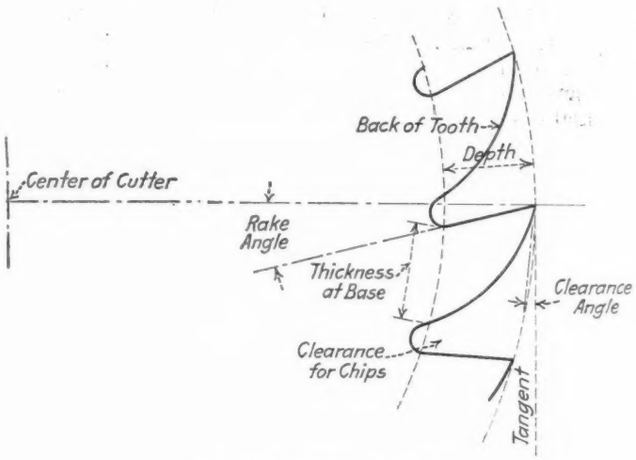


Fig. 3—Definition of Terms

Another way of stating the last paragraph is that the heavier the chip the more metal removed per hp-min. If one were to make a comparison of two cutters with different numbers of teeth but run at the same speed and feed per minute, then obviously the cutter with fewer teeth would remove the metal with less power because the chips are thicker, there being fewer teeth cutting per minute for the same amount of metal removed. It appears illogical, *a priori*, to suppose that the force action of a single tooth under any given set of conditions should be influenced by the location of neighboring teeth, *if free cutting is in operation.* This view is fully substantiated by experiment.

Referring to the preceding paragraph, if the feed has been increased with the fine-toothed cutter in the ratio of a number of teeth in the two cutters (thereby making a chip of the same thickness as with the coarse-tooth cutter), *then exactly the same cubic inches per hp-min. would have been removed as were removed with the coarse-tooth cutter, and more actual cubic inches of material would have been removed per minute, provided the limit of machine power had not been reached.*

If comparative tests had always been analyzed from the point of view of chip volume (or maximum chip thickness, if the depth of cut varies), then the unmerited virtue of wide spacing would never have been recognized.

Shape of Tooth

The following six features of a tooth will be discussed:

a Clearance	*d* Depth
b Rake	*e* Thickness of base
c Shape of back	*f* Clearance for chips.

These features are defined in Fig. 3:

Clearance. Excessive clearance does not reduce the cutting force, does not appreciably affect the life of the tool in normal wear, but does tend to chattering action; also it weakens the cross-section near the cutting edge and increases liability to snip. Clearance should therefore be kept to a minimum. Three degrees was found to be ample but 5 deg. was usually used. In many tool cribs it might be desirable to standardize at 8 deg., due to the possibility of an error of a few degrees. In practice it is customary to speak of clearance in thousandths of an inch at the heel of a land. This is obviously a

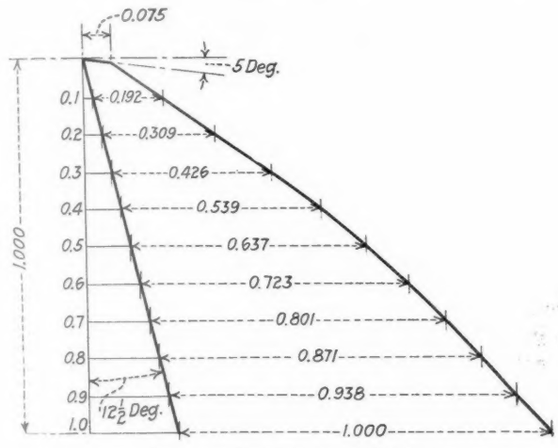


Fig. 4—Ideal Shape of Tooth

safer method, as the heel might bind for any given clearance angle if the land were sufficiently extended. However, for scientific analysis it is better to use degrees.

Rake. From a power-consumption standpoint rake is increasingly beneficial as it becomes greater. The advantage of rake, though, does not increase at so fast a rate after about 15 deg. is passed. Further, this is influenced by the kind of material being cut. On the other hand, the life of the cutter might be influenced disadvantageously by giving the teeth excessive rake.

It is believed that the greater the rake, the longer the life, from a simple abrasion standpoint. An increase in rake, however, necessitates a decrease in the heat conductivity of the tooth, as a consequence of which increased wear due to rising temperature is more likely to occur. A compromise can be obtained only by experiments on endurance and this is treated later.

While the decided power advantage afforded by rake is indisputable, it is not advisable to jump too far in the higher regions. Had the importance of developing cutter design in this direction been acted upon decades ago, as it should have been, then we should be on a much safer footing, as a considerable amount of data would have been available regarding action of greater rakes in all types of situations.

Under the circumstances, the authors believe and recommend that cutters be given 12½ deg. rake; further, that for any definite job it might be very desirable to go beyond this, even as high as 25 deg., but that 12½ deg. may safely be taken as a minimum, with the possible exception of rare and unusual jobs.

Shape of Back. The ideal tooth is that which is just as likely to break in one place as in another. Any deviation from this shape is providing useless excess strength and is detracting from chip room or deleteriously increasing tooth spacing. An ideal tooth shape is given in Fig. 4, with construction data.

Depth. The depth is controlled partly by the length of grinding life expected, but chiefly by the spacing, which in turn will be shown to depend on chip clearance. It is not possible by any method of calculation to predetermine the chip space necessary for given conditions of cut. The space actually needed is a function of the shape of the chip, depending on just how tightly it rolls, manifestly a condition not lending itself to computation.

This feature can be determined only by experiment, but one fact should be kept clearly in mind in considering this, viz., that the shape of the space between teeth is equally important with its net area. The shape should be such as to prevent the chips from "packing," for this quickly causes the power to increase abnormally. Narrow, wedging bottoms must be avoided. The prevention of packing is facilitated by a spiral cutting edge; it is less liable to occur in thin cutters than in thick ones.

Thickness at Base. For a given depth, the thickness at the base is controlled by the ability of the tooth to resist fracture. This is, in turn, dependent on the quality of steel. Thickness at the base is taken as equal to depth in the recommendation here given. This is fairly consistent with present practice and gives an ample factor of safety for cuts that are customary.

Clearance for Chips. Chip clearance should be sufficient to accommodate the heaviest cut that it is desired to take, and no more. It has previously been shown that if clearance is more than necessary or if the cutter is used for chips smaller than the maximum possible, then metal-removing possibilities are being sacrificed. Chip-clearance requirements govern the spacing, and this in turn fixes the number of teeth in a cutter for a given diameter.

Design Formulas. Formulas for determining the number of teeth for a known diameter of cutter and for determining the depth are given below, and a geometrical construction for obtaining shape of tooth has been given in Fig. 4. The arguments demonstrating the rationality of these are given in an appendix to the complete paper.

Let n = number of teeth
R = radius of cutter in inches
d = radial depth of straight face in inches

then

$$n = 19.5\ R^{1/2} - 5.8$$
$$d = 0.215\ R^{1/2}$$

General Consideration of Removing Metal by Milling. It is an interesting and profitable line of thought to consider, in its broadest phases, the problem of removing metal by milling. The first factor to be considered is chip thickness. In order to remove the maximum amount of metal per hp-min. the chips should be as thick as possible.

The chip weight is limited by the endurance properties of the cutting tool, as is also the cutting speed, which is the second factor to be considered. Various experimenters in lathe-tool action have shown that, for a given tool, the chip weight and the cutting speed are interrelated. It should be remarked here that the degree of bluntness permissible in a milling cutter is very slight, when compared with the allowable bluntness of a continuous-cutting tool.

The greatest metal-removing capacity occurs when the product of chip volume and cutting speed is at a maximum. Let us assume that the most advantageous combination of speed and thickness is known for a given tool and material, so that these factors may be kept constant. It then follows that the closer the teeth are together, the more metal will be removed per minute, provided, of course, that the spacing of the teeth is not so far reduced that clogging of the chips takes place. Since power efficiency is determined by chip

thickness only, it is evident that this is not altered by varying the tooth pitch.

If it is possible to keep the feed per tooth constant and decrease the tooth spacing without exceeding the power of the milling machine, the ideal conditions are achieved, i.e., the maximum volume of metal is removed per minute with the expenditure of the least possible power. Suppose, however, that the limit of the machine's power is reached before the minimum possible tooth spacing is obtained.

The problem now assumes a different aspect. We have already obtained the maximum power efficiency by virtue of using the thickest possible chip. If the tooth spacing is to be decreased, the power of the machine will be exceeded unless some of the other factors are changed. If the feed be reduced, the chip becomes thinner. This results in a decrease in the power efficiency coupled with a decrease in the amount of metal removed per minute.

Suppose that we leave the feed constant, decrease the tooth spacing, and at the same time reduce the spindle speed so that the feed per tooth remains the same. The power efficiency will then remain constant, as will the amount of metal removed per minute. Furthermore, the decrease in peripheral speed will result in a lengthening of the life of the cutter between grinds.

We have thus demonstrated that fine spacing is superior to coarse spacing, regardless of whether the cutting speed or the power of the machine be the limiting factor. In the first case, the fine-toothed cutter will remove more metal per minute. In the second case, the fine-toothed cutter will wear longer between grindings, due to the decrease in cutting speed.

Testing the Efficiency of Air Motors

An Apparatus for Determining Whether Machines Are Delivering Full Power Without Waste of Air

By R. M. Arthur

IN view of the great number of air motors in the average railroad shop it is quite important that they be economical in the use of air and powerful enough to perform drilling and reaming operations quickly without consuming more of the mechanic's time than necessary. It is possible to tell in a general way the condition of an air motor by its sound when running and the amount of pull on the handles but this method is unreliable and unscientific to say the least and with the object of getting exact figures on air motor operation the apparatus, illustrated in Fig. 1 for testing air motors, was developed.

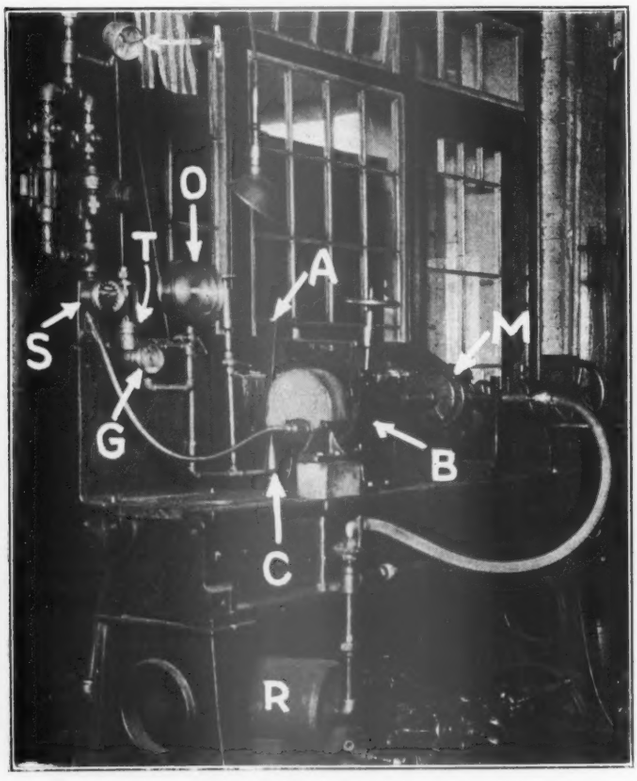


Fig. 1—Air Motor Testing Device on Lathe

The testing bench in this case consists of an old lathe, the tail stock of which is used for supporting the feed screw of the motor *M* under test. The handles of the motor are supported by two adjustable brackets bolted to the lathe bed as shown in the illustration. In place of the lathe head stock, a special casting *D* (better shown in Fig. 2) carries a shaft mounted on roller bearings with a tapered hole in the right end so that by using suitable couplings the shafts can be connected to the shaft of any style of motor to be tested. This shaft also carries a brake pulley 8 in. in diameter which is surrounded with a band brake *B* (Fig. 1) lined with wooden blocks. The brake is prevented from rotating by an arm *A*, 7 15/16 in. long, suitably connected to a piston operating in the small cylinder *C* filled with oil. The hand-wheel illustrated provides means for tightening or loosening the brake band about the pulley and thus controlling the load on the motor. Gage *O* is connected to the oil cylinder through

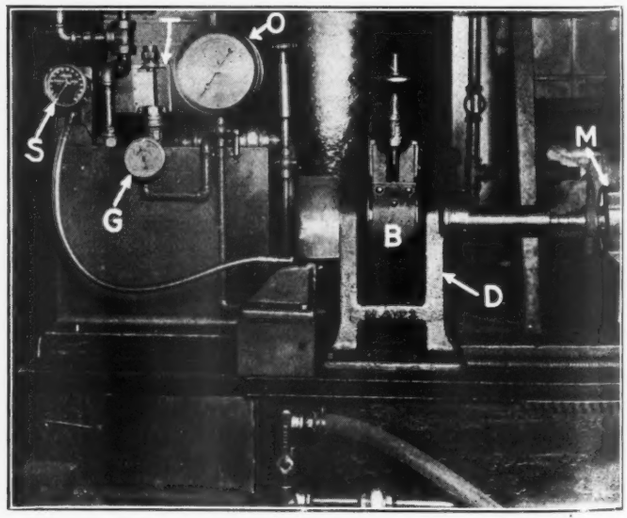


Fig 2—Close-Up View of Brake and Gages

piping and registers the pressure in the oil cylinder, being proportional to the torque developed. The speed of the motor and consequently of the brake pulley is registered by means of a speedometer *S*, the gearing arrangement being such that the speedometer reading, multiplied by five, equals the revolutions per minute of the air motor.

Compressed air, the initial pressure of which is measured by gage *I* is supplied through two feed valves connected in parallel and passes through an air measuring device *I* to the small reservoir *R* and thence by a flexible tube to the air motor under test. The pressure of the air as passing through the measuring device is shown by gage *G* and this is the pressure under which the air motor operates.

In order to eliminate all unnecessary work in calculating the horsepower of a motor under test, the diameter of cylinder *C* which contains the oil and piston resisting rotation of the brake band is determined as follows:

Assume that Hp. = horsepower developed
π = 3.1416
F = total pressure on brake arm in pounds.
R = effective length of brake arm in feet
N = revolutions per minute
r = radius of piston in cylinder *C* in inches
P = pressure indicated by brake gage *O*

Then $\text{Hp.} = \dfrac{2\ \pi\ \text{FRN}}{33000}$

also $\text{F} = \pi\ \text{r}^2\ \text{P}$

In this case $\text{R} = 7\ 15/16$ in. or $\dfrac{7.9375}{12}$ ft.

and $\dfrac{2\ \pi \times \pi\ \text{r}^2\ \text{R}}{33000}$ was made $\dfrac{1}{10000}$

therefore $\text{r}^2 = \dfrac{33000 \times 12}{10000 \times 2\ \pi^2 \times 7.9375} = .253$

and the piston diameter $= \sqrt{.253} \times 2 = 1.006$ in.

therefore $\text{HP} = \dfrac{2\ \pi\ \text{FRN}}{33000} = \dfrac{2\ \pi \times \pi\ \text{r}^2\ \text{PRN}}{33000} = \dfrac{\text{PN}}{10000}$

It is evident then that with the diameter of cylinder *C* equal to 1.006 in. as determined above, the product of the brake gage pressure *O* and the speed of the air motor in revolutions per minute divided by 1,000 will give the horsepower directly without further computation.

Tests were run on a No. 2 air motor, the observed readings and calculated data being shown in the table, the results also being plotted in Fig. 3 for more easy comprehension and comparison. Brake gage pressure, air pressure, brake horsepower developed, air consumption and air consumption per horsepower per minute are all plotted against the speed of the air motor. Referring to the table it will be noted that the air pressure was approximately constant throughout the test which was begun with the motor operating at a full speed of 335 r.p.m. and with no load. Brake gage pressure was increased by turning the hand-wheel and readings taken at eleven different points until the brake gage pressure became 77 lbs. when the motor stalled. Speedometer readings were taken; also the number of cubic feet of free air per minute as registered by meter *T*. The readings of this meter had to be corrected in accordance with a table of correction factors as shown in the first column of the calculated data. The torque in foot pounds is a definite function of the brake gage reading and is obtained by multiplying this reading by the area of the piston in cylinder *C* and multiplying that product again by the effective length of the brake arm in feet. As previously stated, the revolutions per minute equal the speedometer readings multiplied by five; also the horsepower developed is obtained as previously shown; the cubic feet of free air per horsepower per minute is the

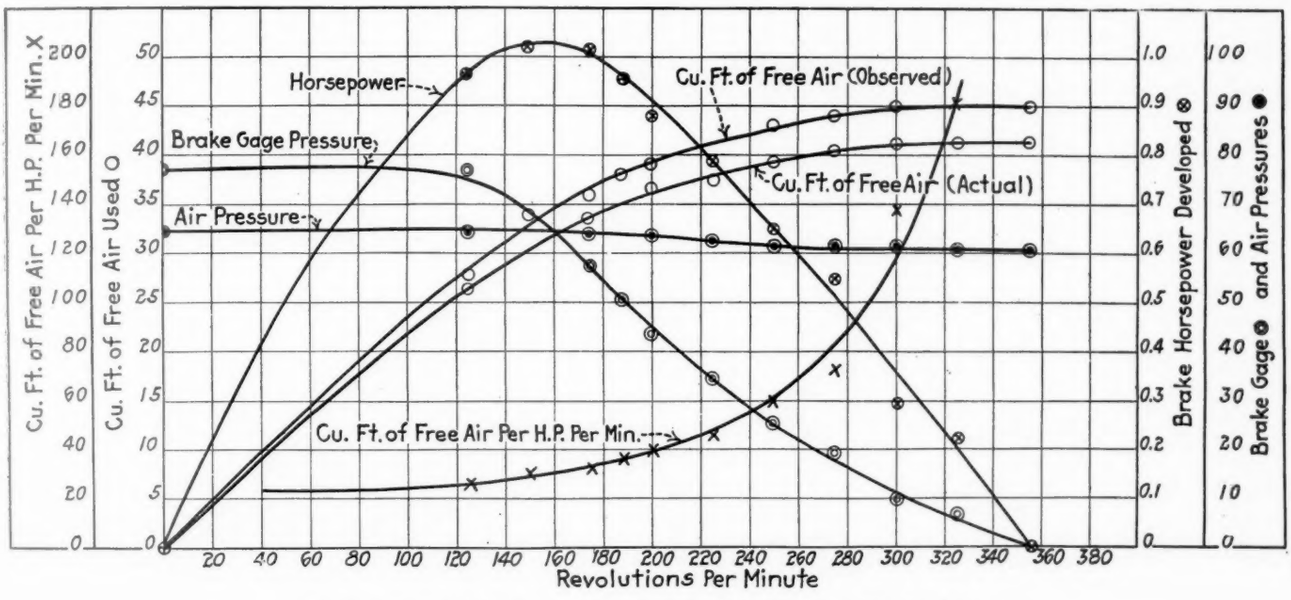

Cu. Ft. of Free Air Per H.P. Per Min. X
Cu. Ft. of Free Air Used O
Horsepower
Brake Gage Pressure
Air Pressure
Cu. Ft. of Free Air (Observed)
Cu. Ft. of Free Air (Actual)
Cu. Ft. of Free Air Per H.P. Per Min.
Brake Horsepower Developed ⊗
Brake Gage O and Air Pressures ●
Revolutions Per Minute

Fig. 3—Curves Plotted from Test Data Showing Air Motor Characteristics

TABLE OF OBSERVED READINGS AND CALCULATED DATA IN AIR MOTOR TEST

Observed readings				Calculated data				
Air pressure in pounds	Brake oil gage pressure	Speedometer reading	Cu. ft. of free air per min.	Cu. ft. of free air per min. (corrected)	Torque in foot pounds	Revolutions per minute	Horsepower developed	Cu. ft. of free air per hp. per min.
61	0	71	45	41.4	0	355	0	...
61	7	65	45	41.4	3.7	325	.227	182
62	10	60	45	41.4	5.3	300	.300	138
62	20	55	44	40.5	10.5	275	.550	73.7
62	26	50	43	39.4	13.7	250	.650	60.6
63	35	45	41	37.6	18.4	225	.790	47.6
64	44	40	39	36.6	23.1	200	.88	41.6
64	51	37.5	38	35.8	26.8	188	.955	37.5
64	58	35	36	33.8	30.5	175	1.015	33.3
64.5	68	30	34	32.2	35.7	150	1.020	31.6
64.5	77	25	28	26.5	40.5	125	.965	27.5
65	77	0	0	0	40.5	0	0	...

quotient of air consumption corrected, divided by horsepower developed.

A glance at the curves (Fig. 3) will show some of the outstanding characteristics of the air motor. The two things in which shop men are mostly interested is the amount of power developed and the air consumed. It will be noted that the actual consumption in this case was lower than the observed but decreased from a maximum amount when the motor was running at high speed under no load. In other words, less air was being used when the motor was operating at a speed of 160 r.p.m. and developing its maximum horsepower than when it was running free under no load.

The practical method of using these curves is to connect up a motor which has been reported defective and measure and record the brake gage pressure and air consumption at a speed of say 160 revolutions per minute. If the brake gage pressure is much lower than 65 lbs. and the air consumption much above 35 cu. ft. of free air per min. it is apparent that the motor is not only failing to develop its rated horsepower but uneconomical in the use of air. The logical thing to do is to give the motor a general overhauling, make sure there is no undue leakage of air past the pistons, take up lost motion and carefully clean and lubricate throughout. The use of this air motor tester should effect important savings by the detection of inefficient air motors and showing up the ones which are wasteful in the use of air. By failure to develop full rated horsepower the latter also consume an undue amount of the operator's time and thus add to the labor costs.

One caution should be observed in making tests and that is to maintain as nearly as possible constant air pressure. The results secured in this test for example were obtained with an air pressure varying from 61 to 65 lb. and would not apply for any other pressure. As a matter of fact, this pressure is rather low (90 lb. is recommended by the motor manufacturers) and particularly in the case of large motors, it may be found necessary to install a booster in the line and obtain a higher pressure. Practically no difficulty will be found in maintaining the brake equipment and speedometer but it may be necessary from time to time to clean out the feed valves and air measuring device to make sure that they are not clogged up and thus rendered ineffective and inaccurate.

Carbonization With Wood Charcoal*

IT would be safe to say that ordinary wood charcoal alone, when considered in comparison with wood charcoal, plus so-called energizers, is little used at the present time. Charcoal has been used and discarded by many hardening and carbonizing rooms but not always for the same reason. The experiments given in this article have been performed on a regular commercial scale to determine the carbonizing effect produced by the use of wood charcoal alone.

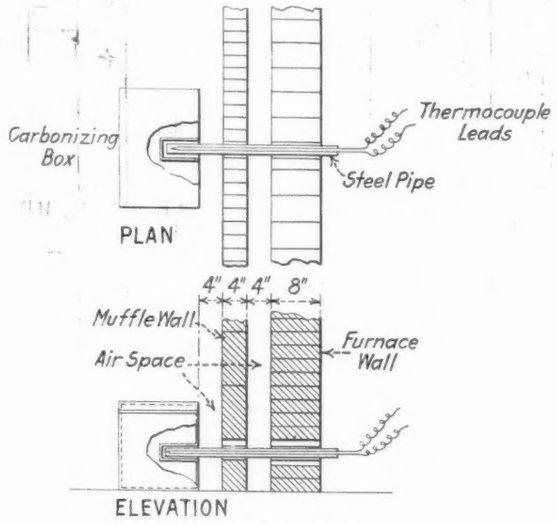
In industry the action of absorption of carbon by steel when heated to the proper temperature for an hour or two in intimate contact with a carbonaceous material is known as case carbonizing, while the same process when extended over a considerable length of time, say a week or more, and where the pieces treated are large with consequent absorption of much carbon, is known as cementation. The former treatment, or case carbonizing using wood charcoal only, is the one under discussion in this article.

In general, to overcome the drawbacks encountered through possible brittleness, the practice of case hardening, or producing a high carbon case on a soft piece of steel is resorted to. There is room for argument and there is considerable diversity of opinion as to whether case hardening is the only recourse at all times, or whether the entire piece of higher carbon and sometimes plus alloys properly heat treated, would not serve the purpose equally well.

With proper treatment of a case carbonized piece after removal from the furnace, and with the elimination of the rather sharp line of demarcation between the high carbon case and low carbon interior, the result obtained is a piece of steel having the desired hard surface with a backing of soft, tough and malleable steel. In short, the latter will not stand wear or abrasion, since it is easily deformed, whereas the former is able to withstand the necessary wear and abrasion. The material used in these tests were drop forgings made from acid bessemer steel of composition approximately: carbon, 0.15; manganese, 0.70; sulphur, 0.050; phosphorus, 0.060 per cent. The pieces were cheap and it is to be noted that the care and time expended in packing did not compare with that for pieces such as gears, which necessarily must be almost perfect.

Method of Conducting Tests

For reasons given later, and explanation of the carbonizing action as understood, it was not deemed essential to take any special precautions as to mesh of the charcoal, although



Carbonizing Box

the material was a powdered mixture with pieces up to 30 mesh. Such precaution as observing that the carbonizing material was free from moisture was considered a routine one, but always should be strictly observed. The procedure followed was to place a layer of charcoal to a depth of one inch on the bottom of the carbonizing box, pack in one layer of forgings each about 12 in. long as closely as possible, cover with charcoal and see that there were no pockets by using a wooden ram; adding another layer of forgings and repeating until about even with the top. Charcoal was then heaped on top of the forgings, the cover pressed down, and the opening around the cover raised at times an inch from the box, and finally luted with a mixture of ordinary clay and water.

After the boxes were removed from the furnace, it was often noticed that as much as one-fourth of the charcoal had been burned, indicating considerable leakage of air into the box because of the cracking of the clay luting. Such condition can be remedied easily by the use of more modern appliances, for example, carbonizing boxes with grooved covers.

In spite of production operations just outlined, the forging when allowed to cool in the boxes and removed, showed a

*A paper presented by H. Schagrin, chief chemist, United States Naval Ordnance Plant, Charleston, W. Va., at the Indianapolis convention of the American Society for Steel Treating.

silvery color indicative of very little surface oxidation. The statement made above that a good portion of the charcoal had been consumed by air leakage, does not necessarily mean that the air came directly in contact with the pieces to be carbonized. The air, from the evidence at hand, must have combined with the charcoal to form the oxide gas carbon monoxide which we know is the real factor in carbonizing.

All up-to-date hardening rooms are now equipped with pyrometers. However, there are many that still depend upon the eye for temperature reading. In such cases, where failure of parts results, it is of course impossible to consistently trace trouble. There has been a great deal written on the proper placing of thermocouples in doing carbonizing work, and care as well as common sense must be exercised in maintaining a uniform temperature in a furnace where there are a number of burners. If the fuel be oil fed from a pump, care must be taken to see that the pulsating action of the pump does not have a direct effect upon the flame. During these experiments some trouble was caused by water in the fuel oil. If the fuel be gas, the proper precaution must be taken to see that the flow of gas is maintained at a constant pressure. The condition of the burners must also be such that the temperature can be regulated easily. The location of the burners are of equal importance.

The carbonizing boxes were all charged when the furnace was at a temperature of about 300 deg. F. The objects of the tests primarily were to determine the amount of penetration that takes place at 1400 to 1500 deg. F. and at excessively high temperature, say 2000 deg. F. Heat treatments are not discussed. Close control was kept at all times on the temperature of the pieces to be carbonized by having the fire end of the thermocouple set in the middle of the box. As an optical indication to the treater, a bar 4 by 4½ in. of the same steel as that being carbonized was inserted in the box in such a way that it could be withdrawn to note the color.

Other Tests

Other work with various kinds of carbonizing materials containing charred leather, powdered bone, charcoal and prussiates in varying proportions, has proven that absorption of carbon by the steel first takes place at about 1400 deg. F., but to produce even a light case at this temperature would require a prohibitive length of time. The determining factors in carbonizing, when comparing the treatment of identical materials and using the same carbonizing compound, are time and temperature. Although it is evident that some carbonizing begins at 1400 deg. F., the time of carbonizing properly should be considered from the time the work has reached the temperature desired.

The standard mixture of 60 parts charcoal and 40 parts barium carbonate intimately mixed gives good results, but is costly. The reaction claimed during carbonizing for this mixture, as forming carbon monoxide and cyanide of barium with the nitrogen of the air, seems less probable than the reaction by which carbon dioxide is released from the carbon dioxide reacting with the charcoal to give carbon monoxide. The next cycle will release oxygen as soon as absorption of carbon takes place, to form more carbon monoxide. The idea has also been advanced that the ash of wood containing alkali carbonates, would form alkali cyanides with the nitrogen of the air. This is doubted, as is the reaction above for the formation of the barium cyanide for the reason that the cyanides formed probably would have more decided effect than is actually the case.

To withstand bending stresses, it is not desirable to carbonize to more than 1.00 per cent carbon. Satisfactory results were obtained by maintaining the work at temperature of 1850 to 1900 deg. F. for one hour. For production work, this allowed two charges per furnace for a working day of 10 hours. It was found that charcoal was a cheap and satisfactory casing material where a normal penetration of about 1/16 in. for about 1½ to 2 hours carbonizing period was desired. For periods over a greater length of time than indicated, other compounds must be present with the charcoal to cause a deeper penetration.

Device for Thawing Frozen Switches

By J. H. Hahn,
Assistant Machine Shop Foreman, Norfolk & Western, Portsmouth, Ohio

DURING severe winter weather considerable difficulty is often caused by frozen switches. An effective device for thawing switches in a minimum time and with little trouble is shown in the illustrations. The thawing is done by a manifold, shown in Fig. 1, fastened to the pilot beam with

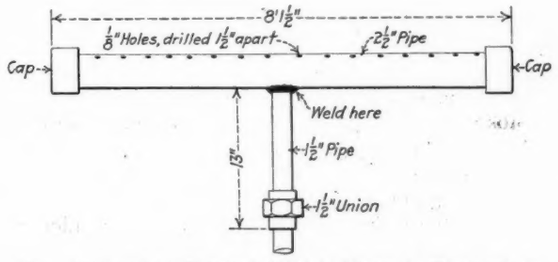


Fig. 1—Manifold Through Which Steam is Directed on Frozen Switches

suitable clamps and placed at right angles to and about four to six inches above the top of the rail. Dry steam is taken from the dome through the connection shown in Fig. 2, and by turning on the valve and moving the engine slowly over the switch points, snow and ice can be melted.

The manifold is made of a piece of 2½ or 3 in. pipe drilled with a row of ⅛ in. holes spaced 1½ in. apart. Caps

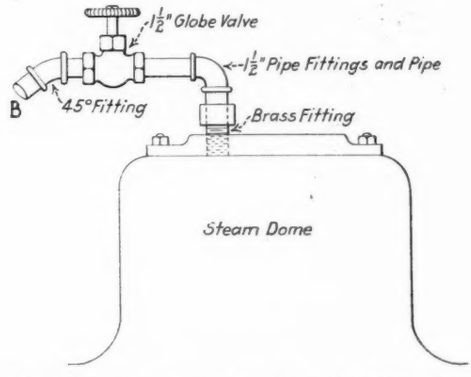
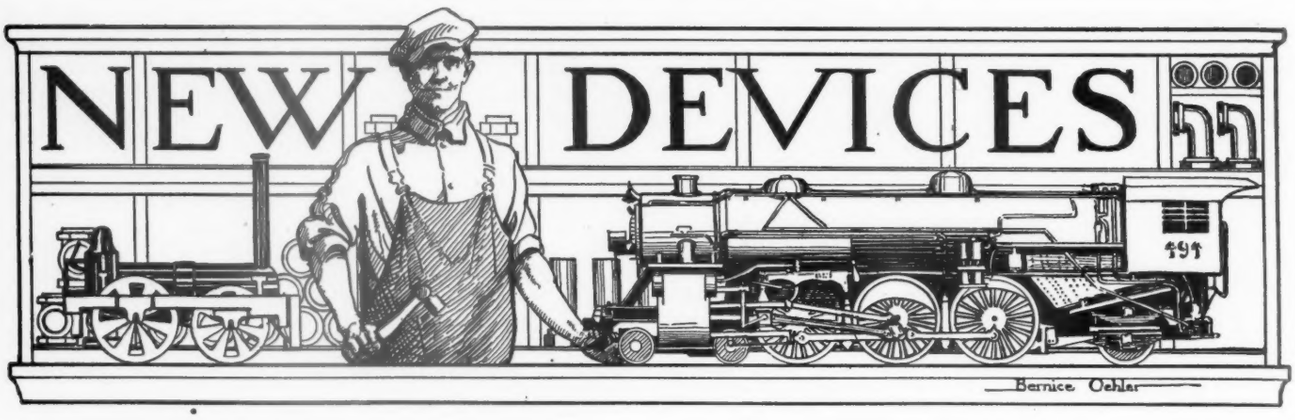


Fig. 2—Dry Steam is Taken from the Steam Dome

are provided as shown, a short piece of 1½ in. pipe being welded at right angles to the manifold. Extra heavy pipe and fittings are used throughout and while only one steam valve was used, it would be possible to put another valve in the steam line on the running board if so desired.

NEW STEEL ALLOY.—According to the Canadian Engineer, A. H. Coplan, managing director of the Hull Iron & Steel Foundries, Hull, Quebec, announces that he has perfected a method for the manufacture of Chromite, an alloy of steel, at a cost not exceeding that of cast iron. "Chromite," says Mr. Coplan, "has a much greater power of resisting the destructive effect of heat than has cast iron, and will therefore be largely used in the manufacture of grate bars for locomotives, steamships, etc."



Improved Hanna Locomotive Stoker, Type H-2

THE Hanna stoker, made by the Hanna Locomotive Stoker Company, Cincinnati, Ohio, belongs to the class in which the fuel is delivered in front of a jet of steam by which it is blown into the firebox and distributed over the surface of the grate.

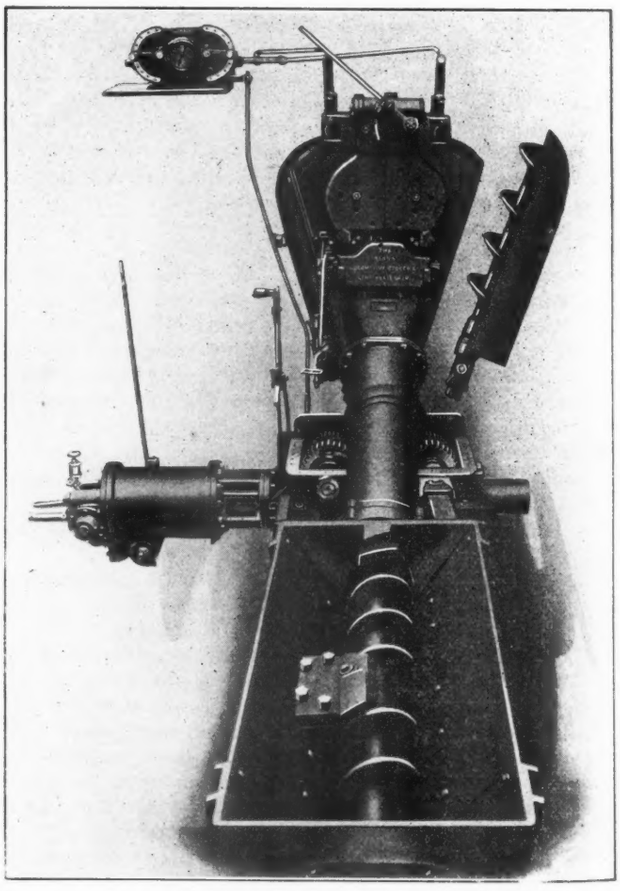
In general the stoker consists of a steam cylinder which, by means of a rack and pinions rotates a screw conveyor by which the coal is brought from the tender to the locomotive. The coal is then delivered to two screw elevators enclosed in a housing embracing the firing door and elevating on each side of the same. These elevators deliver to two oscillating chutes from which the coal drops upon a distributor plate over which it is blown into the firebox and by means of which it is given the proper distribution. The details of the mechanism have been in process of development for a number of years. The speed of the conveyor screws can be varied at will to deliver any desired quantity of fuel; or, in case of clogging or jamming, the conveyor screws can be reversed. Coal may be scattered evenly over the surface of the grate or the delivery concentrated in one place.

Engine and Conveyor of Simple Design

The motive power is derived from a single cylinder steam engine having a diameter of 11 in. and a stroke of 16 in. The valve mechanism is similar to that used in 9½ in, and 11 in. air brake compressors. Should the conveyor become jammed either by large lumps of coal or by foreign substances such as bolts or stone, it may be necessary to reverse the motion of the piston before it has completed its full stroke. To accomplish this there has been introduced a reversing valve of the piston type operated by a lever in the cab through a system of bell-cranks and rods. The two steam passages from the main slide valve, instead of leading directly to the opposite ends of the cylinder, are carried to the reversing valve chamber, the arrangement of ports being such that by the movement of the reversing valve the steam is caused to flow to the opposite end of the cylinder from that to which it flows when the valve is in the other position.

The end of the extended piston rod is coupled to the rack by means of a key. In addition to the usual stuffing box on the cylinder head, the piston rod passes through a second stuffing box on the rack housing, which is an oil tight case. The rack housing is bored out to take the rack guide which is fitted with two side keys. A bearing and wearing strip is inserted between the rack and the rack guide to take the downward thrust of the rack as it works back and forth to drive the gears. The outer end of the housing is closed by a cap, the removal of which furnishes access to the rack.

Mounted on top of the rack housing is the gear box in which is located the nest of gears which drive the screw conveyor and the two elevators. There are two pinions in mesh with the rack which are so connected by gears and clutches to the conveyors that one of the pinions acts as a driver on the out stroke of the piston while the other pinion becomes the driver on the opposite stroke, thus imparting a continuous motion in one direction to the conveying mechanism.



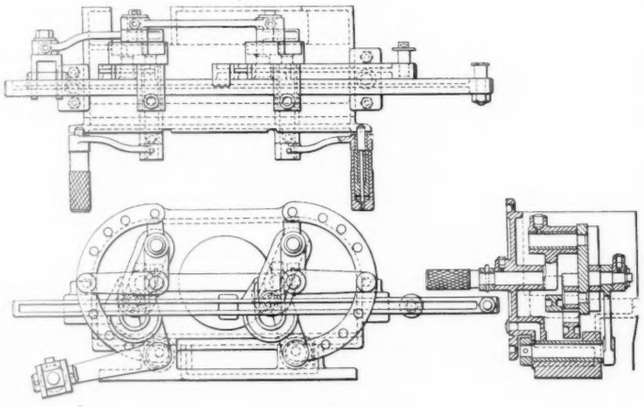
General View of Hanna Locomotive Stoker

A telescoping transmission shaft of square section and equipped with universal joints is located on the right hand side and transmits the driving power from the gear case on the locomotive to the gears at the back end of the main con-

veyor shaft on the tender. This arrangement provides the necessary compensation for the movement between the locomotive and the tender.

The casing of the conveyor on the tender terminates in a ball joint at the front end where it is joined to an inclined circular section which connects the tender to the locomotive. The short conveyor screw in the connecting section is attached to and is driven by the conveyor screw on the tender, a universal joint being used for the connection of the two portions. The elevating screws are independent of the conveyor and are driven direct from the gear case by two universal connections located on the front portion of the gear case.

The pinions driven by the rack are provided with clutches



Control Box

which can be reversed by means of a lever at the left of the firedoor. Should it be desired to run the conveyor screws backward, the pressure on the rack is first relieved by reversing the engine as previously explained, and the gear clutches then shifted to bring the extra gear into action which reverses the motion. In addition to these devices a coupling has been provided at the top of the gear case whereby the transmission shaft may be cut off and the conveyor stopped without shutting down the engine. This clutch is operated by a lever on the deck at the right of the firedoor.

Coal Distributing Mechanism

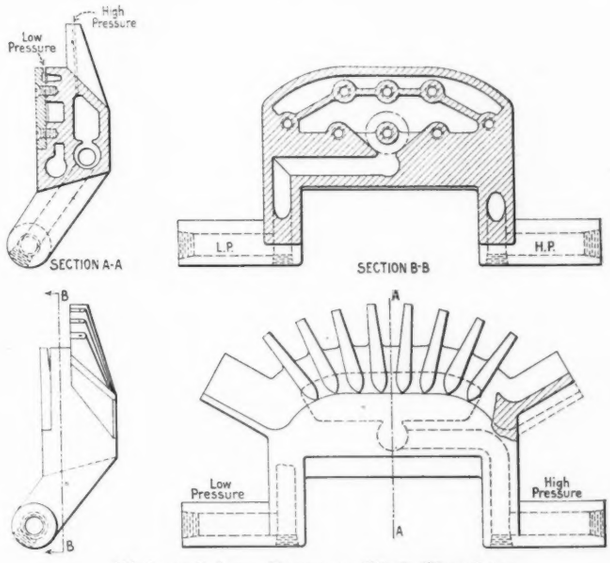
The coal after being conveyed from the tender to the locomotive and raised by the elevators falls upon two oscillating chutes which swing to and fro as they drop the coal onto the distributor plate. This plate, which is an important element in the operation of the stoker, is of cast iron and sets in a casting at the bottom of the firedoor from which it can be easily removed even while the fire is burning brightly. As will be noted from the illustration it consists of a broad flat plate with two curved diverging channels cut into the upper surface. These channels catch a portion of the coal as it is blown over the top of the plate and divert it into the back corners of the firebox along the back sheet.

The cast steel blast chamber is located above and slightly back of the distributor plate. It is provided with two trunnions tapped out for ¾ in. steam pipes, a different pressure being supplied to the two connections. High pressure steam at from 25 lb. to 50 lb. pressure enters through the right-hand trunnion, passes to the upper passage of the chamber from which it is discharged to the firebox through the eight diverging nozzles which are drilled with 5/32 in. holes peened down to ⅛ in. at the orifice. Low pressure steam at from 10 lb. to 25 lb. pressure enters through the left hand trunnion, passes to the lower part of the chamber and is discharged through three nozzles in the plate attached to the bottom of the blast chamber. The combination of the nozzles serves to distribute the coal evenly over the surface of the grates.

The oscillating chutes which deliver the coal to the distributor plate receive their motion from two connecting rods leading to the control box which contains a series of bell-cranks and links. This mechanism receives its reciprocating motion from a crank driven by a worm gear in the main gear case, a rod with universal joints being employed for the connection. On the front of the control box are two levers and handles which are used to adjust the link mechanism and thus regulate the swing of the oscillating chutes. The adjustments for the two chutes are entirely independent and thus provide the maximum flexibility in coal distribution. Should the stoker become inoperative from any cause, the chutes can be disconnected, turned up out of the way and latched; hand firing can then be started immediately. In such a case the coal is simply scattered by shovel on the distributor plate, the stoker blast being used to take the coal from this point and properly distribute it over the surface of the grate.

A duplex gage is also mounted on the front of the control box, the hands showing the steam pressure of the high and low pressure connections of the blast chamber.

By referring to the illustration showing the general rear elevation of the stoker it will be noticed that the main steam pipe leading to the engine is provided with a globe valve and with a ½ in. by-pass pipe having a second globe valve. In ordinary practice the main valve is kept closed, the by-

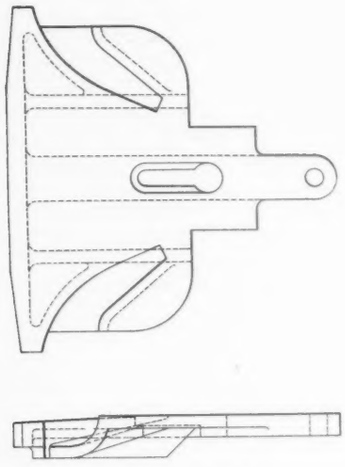


High and Low Pressure Blast Chambers

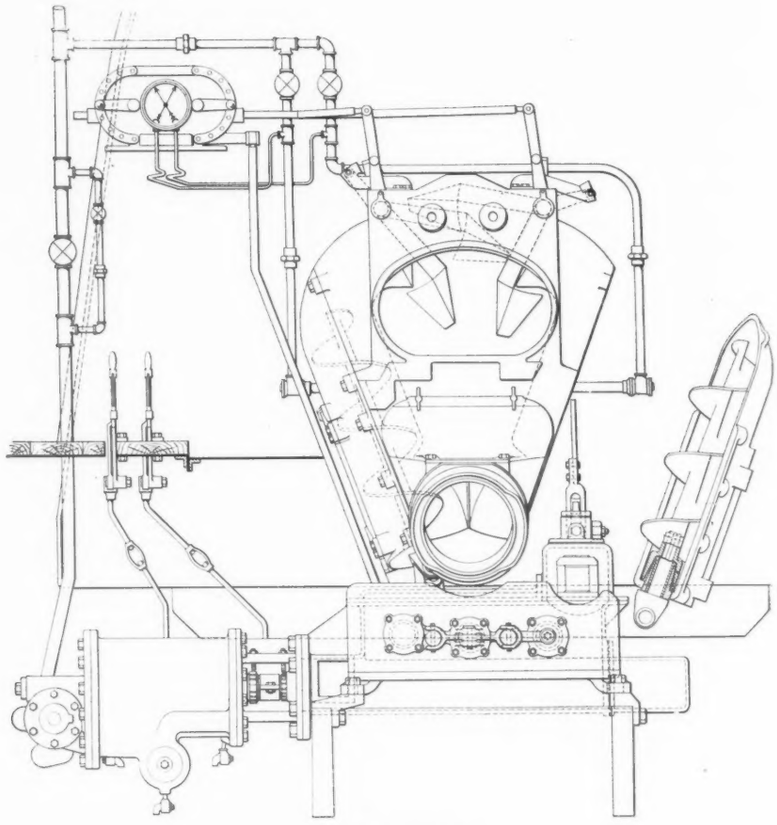
pass pipe furnishing all the steam necessary to operate the engine at the speed required.

Performance on Norfolk & Western

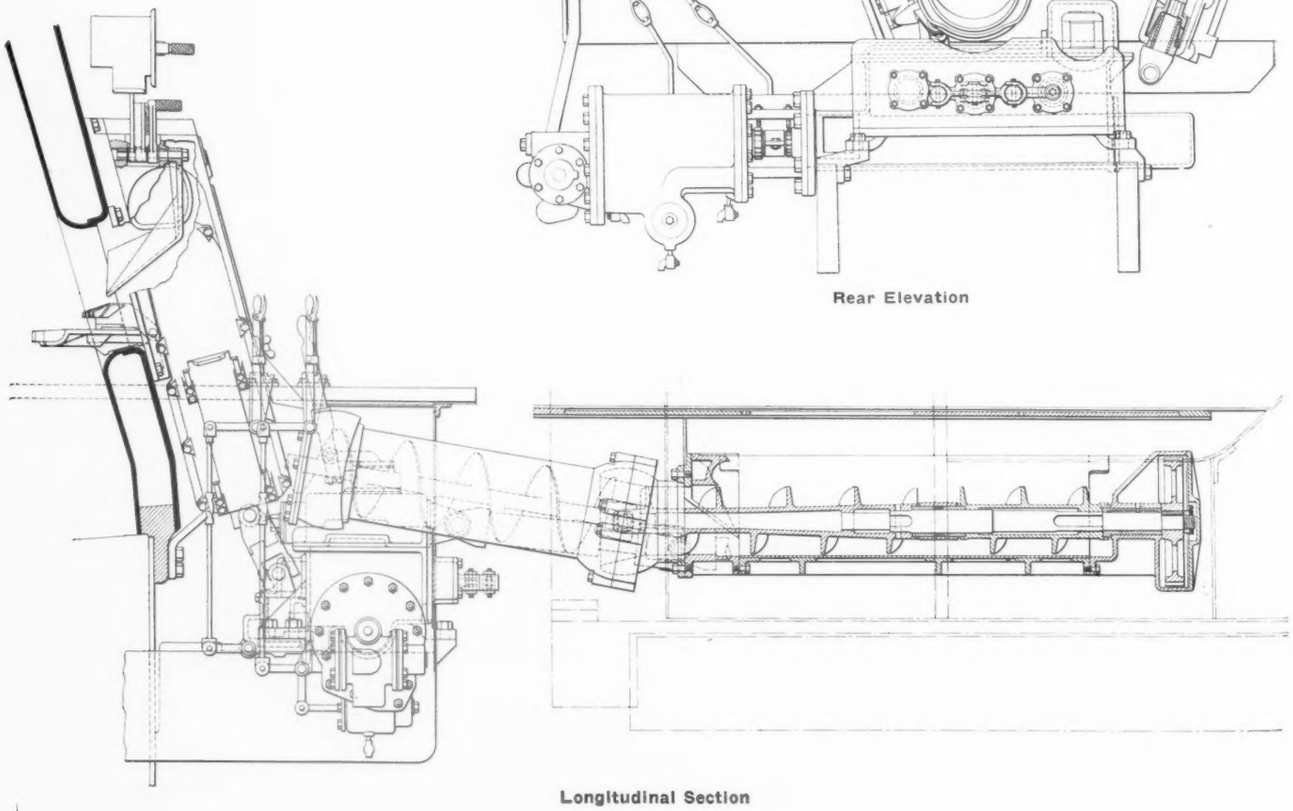
As an example of the performance of the improved Hanna stoker, some notes relative to a recent run on the Norfolk & Western of a locomotive equipped with a stoker of this type will be of interest. The locomotive was of the Mountain type with 29 in. by 28 in. cylinders, 70 in. drivers, 80.3 sq. ft. grate area and a rated tractive effort of 57,200 lb. The run was from Roanoke, Va., to Bristol, a distance of 151 miles and return. On going west from Roanoke the start is over generally rising undulating grades ranging from 0.73 to 0.9 per cent extending for 20 miles to the eastern slope of the Allegheny mountains. Then there is a direct unbroken rise for about 10 miles on a 1.32 per cent grade to the summit, followed by a drop for about 6½ miles on a 1.0 per cent grade to the valley of the New River. Then



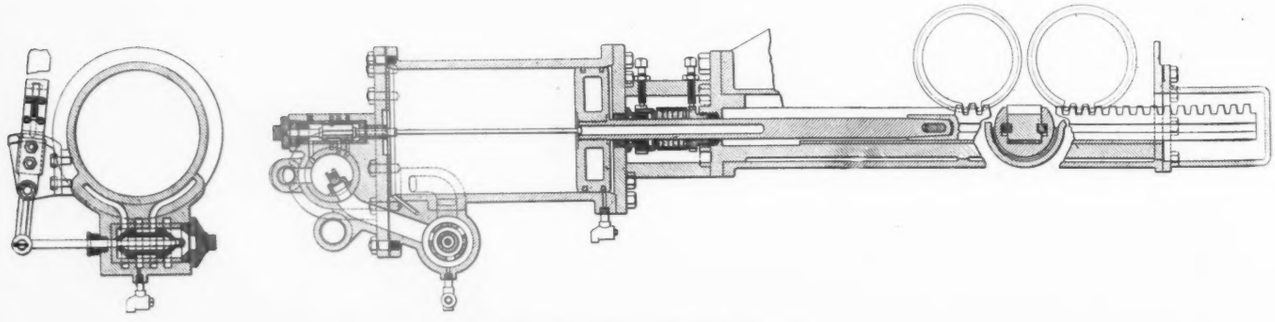
Distributor Plate



Rear Elevation



Longitudinal Section



Section of Engine and Rack Housing

there are four sharp rises on grades running from 1.19 to 1.51 per cent with intermediate drops until the summit is reached at 94 miles from Roanoke, the elevation being 2,591 ft. above sea level. On the western slope there is at first a 10 mile descending grade of 1,125 per cent followed by a series of up and down grades of over one per cent into Bristol, the elevation of which is 1,675 ft., making a net rise of 775 ft. from Roanoke, and a total rise of up grades of 3,540 ft.

On the westbound run, known as the "Memphis Special," the train consisted of a mail car, a combination car, two coaches, three Pullman cars and a dining car, the total weight including the locomotive and the eight cars being about 834 tons. There are no regular station stops but two stops are necessary for water and one for coal. On this particular run there were ten stops including those at flag stations together with those for coal and water; in addition there was one slow-down for track work. The actual elapsed time for the run was 4 hr. 50 min. from which 16.5 min. is to be deducted for stops, leaving an actual running time of 4 hr. 33.5 min., giving an average running speed of 33.1 m.p.h.

On leaving Roanoke there was a brightly burning fire, evenly distributed over the grates, with a depth of about four inches, and a steam pressure of 170 lb. Four minutes after leaving the pressure had risen to 190 lb. and from that time on it swung up and down between 175 lb. and 200 lb. Throughout the run the stoker was controlled by the fireman without having to leave his seat. The rate of feed was governed according to the steam gage and the appearance of the stack. Only immediately after starting there was any appearance of smoke. The fire door was opened by an observer a number of times during the trip when the steam was shut off and in every instance the bed of fire was found to be thin and level.

Occasional adjustments of the steam pressure at the blast nozzles was required but these were slight. Pressure varied from 15 lb. to 20 lb. throughout the run with occasional rises to 25 lb. for the high pressure blast. The oscillating chutes for distributing the coal were untouched except for one adjustment to the right wing. The stoker was stopped 17 times, the total time when it was not in operation being 96.5 min. or about a third of the time. The hook was not taken from its supports, the grates were not shaken and not a shovel full of coal was put into the firebox by hand. On arrival at Bristol the fire was in good condition and was banked without being cleaned.

The return run was a local. There were six cars in the train at the start and one picked up later, the train then being 94 tons lighter than on the trip west. The elapsed time was 5 hr. 43 min. of which 1 hr. 10 min. were occupied at station stops of which there were 33. The actual running time was thus, 4 hr. 33 min. requiring an average running speed of 33.1 m.p.h.

Owing to the frequent stops the stoker required more attention than on the westbound trip. It was stopped 32 times and was idle for a total of 2 hr. 19.5 min. or 41 per cent of the elapsed time. The distributing chutes were adjusted nine times. The pressure at the high pressure nozzles varied from 15 lb. to 30 lb. and at the low pressure from 10 lb. to 30 lb. The steam pressure was maintained between 175 lb. and 200 lb., the average being 192 lb., and the safety valves did not open.

On leaving Bristol the fire bed was rough and humpy as left from burning down over night after being banked, but within 10 min. after the start it was in a smooth even condition. As on the trip west, the fire hook was not used, no coal was fired by hand and the grates were not shaken. On arrival at Roanoke the fire was thin, level and burning evenly.

The coal used was prepared for stoker operation in accordance with the practice on the Norfolk and Western and was of the usual grade which contains about six per cent ash and 36 per cent volatile matter.

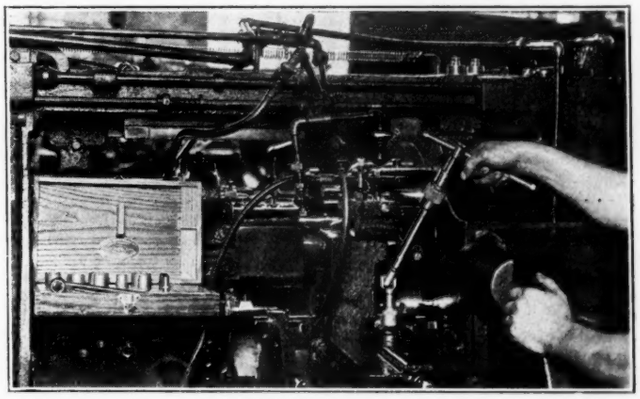
The run was not an unusual one as the records of the locomotive show that for 28 consecutive runs no coal had been fired by hand, the hook had not been used and the grates had not been shaken.

Convenient Socket and Ratchet Wrench Set

THE illustration shows the use on an automatic screw machine of a new socket and ratchet wrench set placed on the market recently by the Eastern Machine Screw Corporation, New Haven, Conn. This wrench set has been designed to meet the demand for a stronger and more durable socket wrench with provision for greater convenience in handling. The set is packed in a strong wooden box in which a place is provided for each part so that the absence of any part is readily noticed.

The most important feature of the set is in the construction of the sockets. The usual practice is to obtain the hexagon hole by drilling the end of the socket to the diameter conforming to the dimensions across the flats and then broach this hole to a hexagon shape. This forces the metal outwards, producing the corners but naturally sets up a strain which is only compensated for by making the walls of the socket thicker. The hexagon hole in the H. & G. socket is made by drilling the hole to the diameter corresponding to the diagonals; that is, the distance across corners at the maximum point, and then the metal is drawn in to form the hexagon during which process the metal is compressed and toughened.

The H. & G. sockets are provided with a strong hexagon head, all of the different wrench parts fitting over this head for turning. All of the sockets are especially heat treated and hardened after being machined to fit the nuts accurately. The set is provided with an adjustable tee handle so that it can be used in a central position for fast work or adjusted for maximum leverage. The ratchet is compact and strongly designed and may be made either right or left hand by simply raising and reversing the position of a ball headed pin.



H. & G. Socket and Ratchet Wrench Reaches Nut in Difficult Place on Automatic Screw Machine

An extension piece is provided to be used between the tee handle and the socket either to turn nuts otherwise difficult

to reach or to bring the tee handle to a more favorable position. A universal joint allows for turning nuts located at difficult angles, this joint being milled from bar stock. Two screw drivers which fit any of the other attachments are provided. The box wrench is included in the set primarily to provide a method of getting at nuts in connection with the sockets where the head room over the nut will not permit the use of other tools. This is a drop forging so designed that the sides of the wrench are wide and flat and permit the use of maximum pressure with minimum discomfort. The box wrench is hardened by the cyanide process. Each female part of the wrench attachments has a split screw made from spring steel which provides the proper amount of friction to hold the different parts together while in use.

Semi-Automatic Valve Finishing Machine

As the result of extended and careful experiments under everyday working conditions in the air brake repair department of a large railroad shop, the semi-automatic valve finishing machine, illustrated in Fig. 1, has been developed. It is used mostly in the repair of brake valves and triple valves, the advantages claimed being larger production, more accurate fitting and increased life of wearing surfaces.

The present method of fitting rotary valves, slide valves and graduating valves to their seats is largely by hand scraping and lapping to a flat surface plate, an operation which requires one man to one part until a practically perfect surface is obtained. After this the seat in the valve body is filed and then scraped to the slide valve ieself. The machine, illustrated, is designed to finish mechanically both slide valves and seats in such a manner as to make

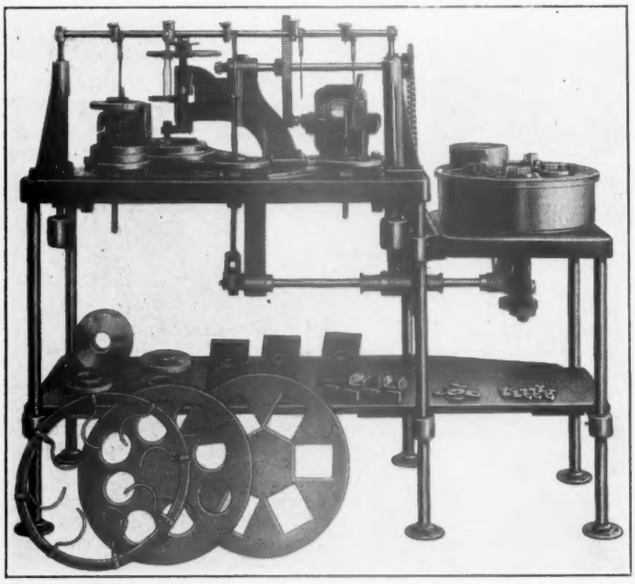


Fig. 1—General View of Semi-Automatic Valve Finishing Machine

them practically interchangeable, thus eliminating to a large extent the human element, since it is generally conceded that only the most expert and careful workmen can scrape and lap the intricate valves at present in use and maintain a flat surface to the edges of all ports and openings.

Capacity and Production

The machine as designed will handle all of the parts of air brake equipment listed below, the carriers or workholders being arranged to receive at one time the number set against each item: Three seats, or 8 rotaries, for engineer's brake valves; 6 seats, or 11 rotaries, for independent brake valves; 18 slide valves, or 24 graduating valves, for triple valves; 18 slide valves for distributing valves. It is also practical to operate on a variety of parts as necessity may require.

The rotary portion of the machine with several air brake parts being lapped is shown in Fig. 2 which illustrates the convenience with which parts can be removed for inspection or new ones applied. The rotary portion, including the lapping plate and the carrier or workholder, are so arranged that they rotate in opposite directions and eccentric to each

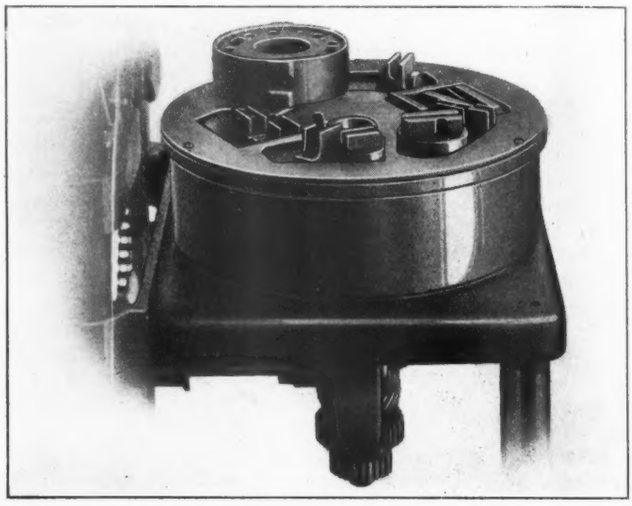


Fig. 2—Close-Up of Rotary Portion with Air Brake Parts Being Lapped

other. The ratio of speeds is such that the work is constantly changing its position on the lapping plate, a condition which results not only in flat surfaces but tends to keep the lapping plate true for the maximum length of time. The

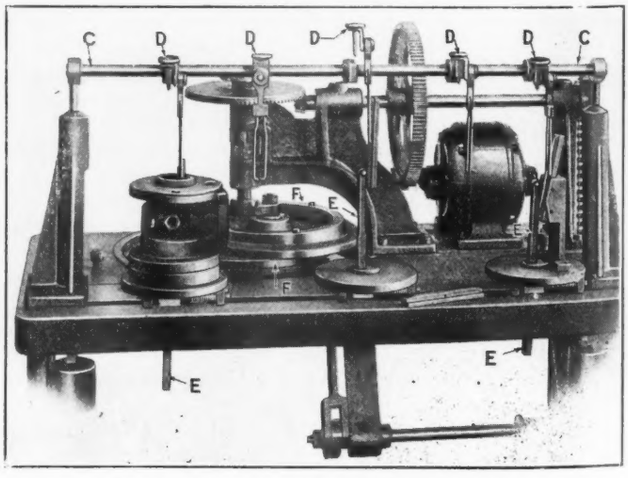


Fig. 3—View Showing Details of Reciprocating Portion

time required with one operator for obtaining a practically flat surface ranges from 5 to 15 min., including the application of abrasive, inspection and keeping the lapping plates in necessary true condition. Twenty complete rotaries and seats of engineer's brake valves, for example, or 25 or more

complete triple valves can be handled easily in eight hours.

The reciprocating portion of the machine where the seats in the bodies of the triple valves themselves are finished is shown in greater detail in Fig. 3. Provision is made for five triple valves, or that number of seats in other valves at one time; the lap sticks are mechanically moved about one inch while held at the desired pressure against the surfaces to be finished. One station has a fixture in which the slide valve is placed for finishing the seat for the graduating valve. The lap sticks may be kept in proper condition on the rotary lapping plate in the same manner as the slide valves.

In Fig. 3, the reciprocating bar *C C* carries the lap sticks on which are five members *D* horizontally adjustable for properly locating the lap sticks in relation to whatever type of valve body or graduating valve seat it is desired to finish. The method of removing the lap sticks for changes or the application of abrasive without stopping the machine is shown at the center fixture. The pressure bars for holding the lap sticks against the valve seats are shown at *E*. These are adjustable to give the desired pressure and automatically drop down out of the way when the lap is removed. For keeping the rotary lapping plates in proper condition a mechanism is provided at the back of the machine causing two plates *F F* (Fig. 3) to work against and true each other while the third plate is in actual use. This lapping plate truing mechanism requires practically no attention, the plates being changed not more than twice a day.

During the operation of this valve finishing machine any one part being finished can be removed for inspection, or new pieces applied without stopping or in any way interfering with those already in the machine. By this means it is said that one man operating one machine will produce an amount of repair parts of air brake equipment many times in excess of the possible output by present methods, with the further advantages of a more accurate flat surface throughout and longer service between repairs. The machine is driven by a ¼-hp. motor or tight and loose pulleys, with two hand-operated clutches allowing each portion to be operated independently. It has been placed on the market by the Walter H. Foster Company, New York.

Safety Locomotive Ash Pan Blow-out Valve

FOUR distinctive features and important advantages are claimed for the new locomotive ash pan blow-out valve illustrated; namely, safety, elimination of packing troubles, small space occupied and automatic closure. Patents are now pending on the device which has been developed by Arthur Brigham, an employee of the New York, New Haven & Hartford at the Dover street roundhouse, Boston, Mass. Several of the valves have been made and applied and they are recommended with considerable enthusiasm by the men responsible for their maintenance and operation.

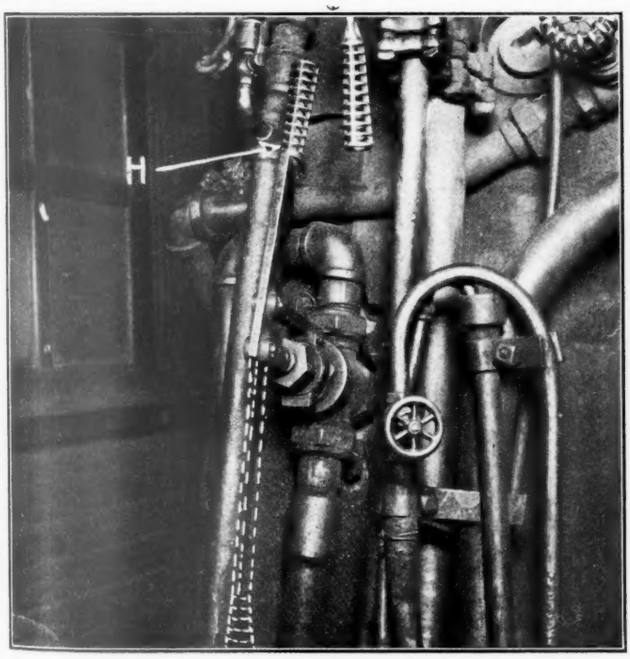


Fig. 1—Brigham Ash Pan Valve Applied to Boiler Head

Referring to Fig. 1 the valve will be seen applied to the back head of a locomotive boiler with handle *H* in the upper position. A direct, steady pull on the handle will admit steam to the body of the valve and direct it to the upper pipe, and connecting pipes to the front ash pan. When the ash pan has been cleared of ashes, handle *H* is released and automatically goes back to the closed position, shutting off the supply of steam. This is an important feature since, should anything happen to the fireman or hostler while operating the valve, it will close automatically. When it is desired to blow out the rear ash pan, handle *H* and its fulcrum lever are revolved parallel with the boiler head to the lower position, shown in dotted lines. A direct pull on the valve handle when in the lower position will admit steam from the boiler to the valve and the lower pipe and then through the connecting pipes and fittings to the rear ash pan. As in the previous case the valve is closed automatically by releasing the handle.

The safety feature of the valve can be more plainly seen by referring to Fig. 2 in which the valve is shown disconnected from the boiler head. It is apparent from the illustration that the valve screws into the boiler head at thread *A*, check valve *B* which controls the flow of steam being inside the boiler sheet. The blow-out valve is grooved internally just to the left of thread *A* so that should the valve receive an accidental heavy blow it will break at this groove, leaving thread *A* and check valve *B* intact. Referring to Fig. 2 the operation of the valve and handle will also be more readily apparent. The movement of handle *H* to the left opens check valve *B*. A one-ported hollow internal sleeve is pro-

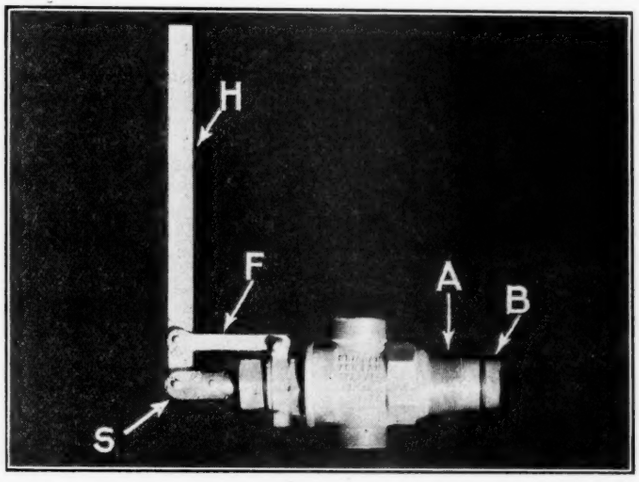


Fig. 2—View Showing Location of Check Valve

vided in the valve and directs the flow of steam into the upper or lower pipes, depending upon the position of handle *H*. Reference to Fig. 1 shows the small amount of room required for the valve and it is stated that owing to the absence of steam from the blow-out valve when not in use no packing is needed.

Semi-Automatic Arc Welding Lead

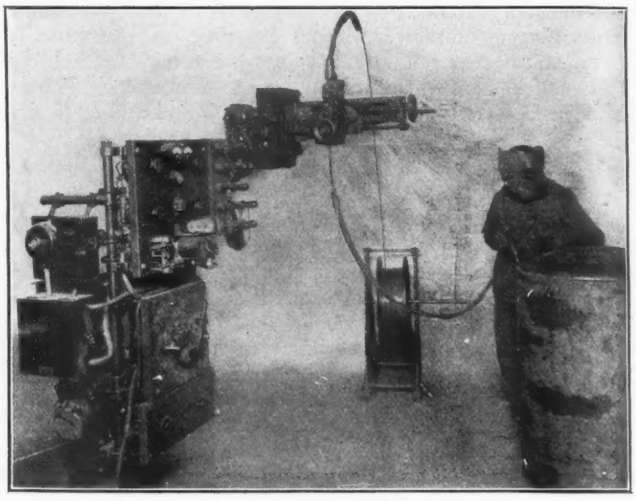
A SEMI-AUTOMATIC arc welding lead has just been developed by the General Electric Company, Schenectady, N. Y., for use in conjunction with its automatic arc welding head, which retains the continuous features of the automatic apparatus, yet allows the operator to direct the arc as required by the conditions of the work.

The apparatus consists of a welding tool to be held by the operator, which acts as a guide for the electrode wire. In the handle of the tool, which greatly resembles an automatic pistol, is a switch for operating the control on the panel of the automatic welder to start and stop the movement of the electrode wire. Attached to the tool is a 10-ft. length of flexible steel tubing, called the "flexible wire guide," with an adapter on the other end for attaching it to the automatic welding head. The wire passes from the feed rolls of the head into the flexible tubing, and thence to the arc through a "guide nozzle" in the welding tool. The automatic welder functions, tending to hold the arc length constant, and the operator merely directs the arc as required.

The field of application of the semi-automatic lead is the welding of products where the seams to be welded are of very irregular contour, or on very large work where the travel mechanism and clamping necessary for the full automatic welder would be complicated and costly. In many cases the edges of the seams are not accurately prepared, making gaps in some places and tight fits in others. The automatic welder with mechanical travel cannot compensate for these conditions by varying the speed, or by manipulation of the electrode, but with the semi-automatic, they are taken care of.

The semi-automatic welder may also be used for building up metal rapidly, as in the case of the filling up of blow holes in castings, or the building up of worn spots, etc. The speed of deposition of the metal varies widely, being somewhere between the ordinary hand speed and that of the automatic, according to the conditions of the particular job. In general it is about twice as fast as hand welding.

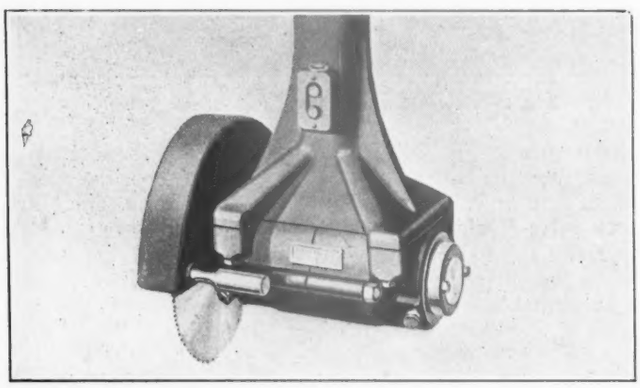
The advantages claimed for the semi-automatic welding equipment may be summed up as follows: (1) Saving in time which is ordinarily lost in changing electrodes; (2) Saving of from 10 to 20 per cent in electrode material ordinarily thrown away as waste ends; (3) Operators can become proficient in the use of the tool very quickly, as they do not require the muscular training necessary for hand work; (4) Continuous operation results in few interruptions in the welding, each of which is a potential source of defective welds.



General Electric Semi-Automatic Arc Welder

Motor Head for Swing Cut-Off Saw

A NEW motor head has been developed for the swing cut-off saw made by the Oliver Machinery Company, Grand Rapids, Mich. The swinging frame of this saw is of the usual Oliver construction, it being made in a cored form with a single arm which is centrally located. This arm is made in three standard lengths, namely 5 ft. 5 in., 7 ft. 5 in., and 9 ft. 5 in. The saw arbor, shown in the illustration, is made of crucible steel and machine ground to an accurate size.



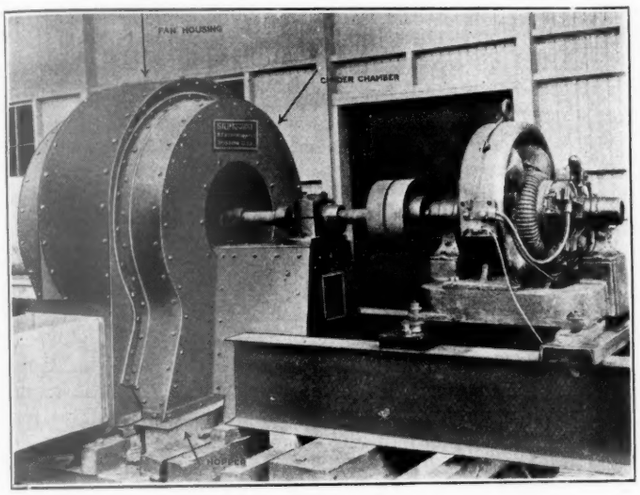
Head Construction of Oliver Motor-on-Arbor Swing Cut-off Saw

Two types of electric drive can be furnished if desired, either belted motor drive or the motor-on-arbor type, illustrated. The belted motor drive consists of mounting a 5-hp., 1800 r.p.m motor on a bracket in the yoke of the machine in place of the countershaft, and belting down to the saw arbor. The motor-on-arbor can be furnished only for two or three phase, 60 cycle, 220 or 440 volt a.c. and consists of a 3-hp., 3600 r.p.m shaftless motor built in directly on the saw arbor, fitted with ball bearings and a 16-in. diameter saw with guard in handle. This motor-on-arbor drive is said to be extremely efficient, dependable, and safe, requiring a minimum of care. The motor is stopped and started by means of two push buttons on the arbor. The entire construction is rugged and the saw can be used effectively with the swing cut-off saw table, described on page 432 of the June 1921 *Railway Mechanical Engineer*.

Cinder Separating Induced Draft Fan

WITH the idea of separating cinders and dust from exhaust gases and thus greatly reducing the smoke nuisance, the B. F. Sturtevant Company, Boston, Mass., has developed a cinder-separating, induced draft fan, shown in the illustration.

The fan housing is indicated by an arrow, also the cinder



Sturtevant Fan Designed To Separate Dust and Cinders from Flue Gases

chamber and the hopper in which dust and cinders collect by gravity. Buckets are provided at the inlet edges of the blades of the paddle wheel. These buckets catch and separate the dust and cinders which are conducted by means of inclined channels leading out into the special dust chambers in the fan. Several small guiding vanes serve to direct the air and cinders into the inclined channels. Since it is impossible to blow dust with air as this would involve again a separation problem, arrangement is made for the dust to settle and fall by gravity into the dust chambers. These dust chambers lead to the closed hopper at the bottom in which the dust accumulates and from which it can be removed periodically or continuously by means of screw or other conveyors.

The cinder-separating fan takes no more room practically and requires no more attention than an ordinary induced draft fan. It is said to be unusually efficient as a fan and to remove 75 per cent of the solid matter in the gases. The fan removes a still larger proportion of the heavy coarse material which drops over the city in the neighborhood of power plants causing complaints from the residents. Two of these fans have been installed in a large power plant in New York City and are reported to operate successfully. They are used in connection with six 500-hp. boilers and when these boilers are operating at 200 per cent rating, it is found that each fan removes 250 lb. of cinders per hour. At higher ratings this would be much greater. The material resembles a fine coke breeze and on an analysis shows about 9,700 B.t.u. per pound.

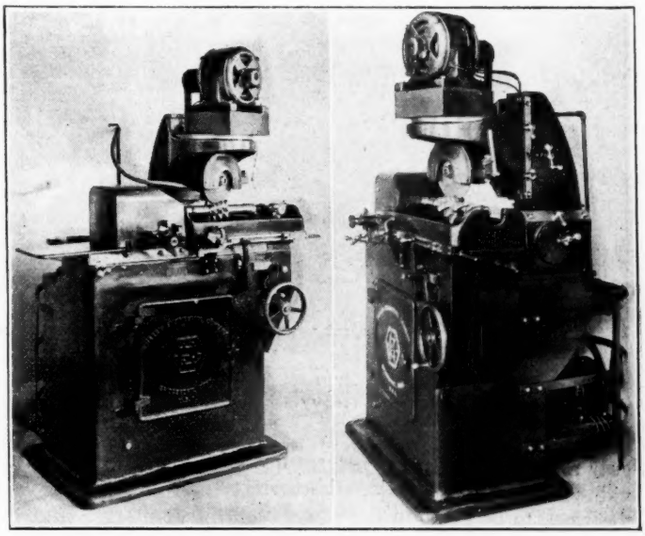
The cinder eliminating induced draft fan is particularly desirable for use with underfed stokers. These do not cause a serious smoke nuisance when boilers are operating at normal ratings. They do, however, when the boilers are being forced above normal ratings. Extremely fine particles in the smoke are not particularly objectionable because they are carried away by the air currents and not deposited over the surrounding neighborhood, but the dust and cinders in the gases are fairly heavy and fall within a comparatively short distance of the stack; hence the need of an efficient cinder-separating fan.

Improved Automatic Hob-Grinding Machine

THE automatic hob grinder illustrated is made by the H. E. Harris Engineering Company, Bridgeport, Conn., and combines many important improvements over the original machine of this type described on page 551 of the August, 1920, *Railway Mechanical Engineer*. In the 1920 model, the motor drive for running reciprocating parts of the machine was mounted on rails on the floor instead of on an integral bracket on the back of the machine itself. This arrangement makes the present motor and machine self-contained. The maximum spiral now possible at eight inches diameter is 47 deg. either right or left as against 23 deg., the maximum helix formerly possible to grind. In the new model, ball bearings are used instead of a sliding block to transmit the spiral action from the adjustable angular slide way at the back. Increased life of the spindle bearings is now obtained by using heavy bronze bushings with positive adjustment for wear instead of the ball bearings formerly used.

The machine illustrated is 20 per cent heavier than the 1920 model and the table has less overhang from the bed at the end of its stroke. The column at the back is made heavier and the slides longer. The overhang of the wheel has been decreased to a minimum, making it much stiffer in this respect. The index head has been redesigned, made heavier with larger bearings and the latter placed further apart so that except for the heaviest hobs, it is not necessary to support the outer end of the work arbor with the tail center, thus saving considerable time in changing from one hob to another.

The arrangement for wet grinding has been changed using larger valves and pipes and a deeper pan so that about double



Harris Motor-Driven Automatic Hob Grinder

the amount of liquid can be used in cooling as heretofore. This liquid is returned to the settling pan in order to keep it clean. It is said that dry grinding invariably reduces the

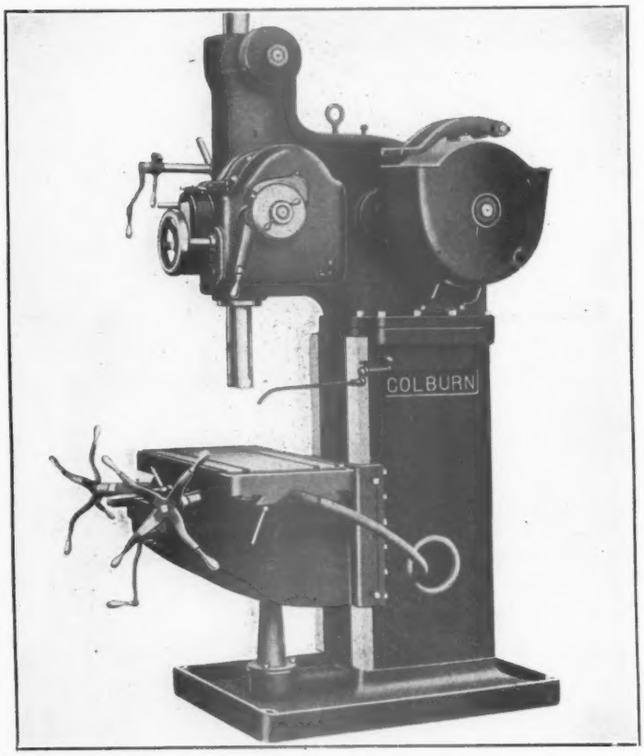
scleroscope readings on the cutting edges and records show that wet ground hobs stand up longer and produce more work between grindings. The machine may be set to compensate for the wear of the wheel, so that after the wheel has partly ground a hob and is itself partially worn away, it will still grind radially. This is an important feature as is also the adjustment provided so that hobs, where desired, may be ground undercut or with "hook" to the teeth, according to the practice now coming into general use. All adjustments can be made by the operator from the front of the machine and most of these adjustments can be made when the machine is running.

The 1920 machines were made with a fixed table stroke, being driven by a face cam. On the new model the work table is driven by a clutch reverse gear mechanism operating a pinion in a rack, and adjustable stops on the front edge of the table allow adjustments to any length of hob within the capacity of the machine. This eliminates the time lost in the earlier fixed maximum stroke cam-driven machine on grinding short hobs.

A diamond truing device (not shown in the illustration) is built into the head which replaces the old style separate diamond truing device, operated from the work table. While there is no radical change in the general design of the machine, the above represents a number of important improvements and differences between this machine and the 1920 model said to make it at least 50 per cent more effective than the older machines.

Heavy Duty Manufacturing Drill Press

SIMPLICITY of construction and the elimination of all unnecessary running parts are advantages claimed for the new No. 6 heavy duty drill press made by the Colburn Machine Tool Company, Cleveland, Ohio, and shown in the illustration. This tool is designed for the machining of duplicate parts in quantities but can also be adapted to handling a large variety of work inasmuch as a large range of speeds and feeds is possible due to a special transposing gear arrangement. This insures unusual flexibility and provides a means of securing the correct feeds and speeds for the work to be performed.



Colburn No. 6 Heavy Duty Drill Press

Features of design tending to add to the value of the machine as a production tool include the heavy box-type head; rigid table and column; the stub tooth, chrome-nickel steel drive gears, heat treated and hardened, running in a bath of oil; drive shafts of large diameter and short lengths; the use of ball bearings throughout the drive and finally the location of the spindle driving gear at the lowest point of the head and on the large diameter of the spindle.

The machine has a capacity to drive three-inch high speed drills in solid steel, the rated swing of the machine being 28 in. The distance from the center of the spindle to the face of the column is 14 in. and the maximum distance from the nose of the spindle to the standard table is 36 in.; to the compound table, 30 in. The spindle travel regularly provided is 18 in.

All levers and hand wheels are located on the front of the machine and the operator can make speed and feed changes without moving from his regular working position.

Two mechanical speed changes are provided which in conjunction with a special arrangement of change gears makes it possible to obtain 48 different spindle speeds ranging from 30 to 375 r.p.m. Two mechanical feed changes are provided which with different change gears gives 36 speeds ranging from .005 in. to .134 in. per revolution of spindle.

The illustration shows the machine equipped with a plain table of rigid construction but a compound table can be provided if desired. Every mechanical precaution is said to have been taken to safeguard the machine and operator against injury from accidents or carelessness. The feed mechanism is provided with a safety device which shears a pin before damage is done. An interlocking device makes it impossible to change the speeds while the machine is running, also making it impossible to start the machine until the speed sliding gears are fully in mesh.

An automatic tripping mechanism can be set to trip the feed at any desired depth and a final safety trip is also provided for the feed when the spindle has reached its lowest position, thus avoiding possible accident.

When desired, a motor drive can be applied to the machine with a constant speed motor mounted directly on the lower part of the column at the rear and belted to tight and loose pulleys. A 10- to 20-hp. motor is recommended depending upon the work being done.

When desired, a machine of the same general type can be furnished as a two-, three- or four-spindle gang drill.

A Correction

In the description of the Tri-way Universal horizontal boring machine, made by the Universal Boring Machine Company, Hudson, Mass., published on pages 44 and 45 of the January *Railway Mechanical Engineer*, two errors were made. Boring feeds were incorrectly stated to vary from 1 in. to 2-13/16 in. per min. This line should read "Boring feeds vary from ⅛ in. to 2-13/16 in. per min." The weight of the machine crated was given as 2,200 lb. and should have been 22,000 lb.

GENERAL NEWS

The Nashville, Chattanooga & St. Louis, on January 9, changed its engine terminals from Lexington, Tenn., to Hollow Rock Junction where new repair shops and other buildings will be provided.

L. A. Downs, vice-president and general manager of the Central of Georgia, and chairman of Division IV of the American Railway Association, has been appointed a delegate of that association to attend the Congress of the International Railway Association at Rome, Italy, in April next.

The National Safety Council, Chicago, is now taking a census of those who are directly charged with the duty of promoting safety through inspection safety investigations, safety education, control of health hazards, or similar work in industries and on the railroads. This is the first time any attempt has been made to obtain a census of the persons engaged professionally in the safety movement.

The enginemen and firemen of the Southern Pacific operating their locomotives with the greatest efficiency in the use of fuel oil, are to be awarded gold badges. The name of the winner with the date of the award is to be inscribed on the back of the medal. If a man wins an award a second time, a red enameled star will be inserted in the badge. The award is to be made on a three months' performance basis.

Passenger train punctuality on the Pennsylvania railroad during the year recently ended is reported as 11 per cent better than the previous year. For the period from March to December, inclusive, for the two years, 93.9 per cent of the passenger trains operated were on time in 1921, as against 82.5 per cent on time during the same period in 1920. In 1921 the percentage of trains making schedule time was 96.8, an improvement over 1920 of 4.8 per cent.

The Summary of Wage Statistics, issued by the Interstate Commerce Commission for the month of September, 1921, compared with August, shows an increase of 38,403 in the number of employees of the railroads of the country as of the middle of the month, while their total earnings decreased $3,773,073. The number of employees was 1,718,330, and their total compensation was $223,972,822. The decrease in earnings is said to be due to the fact that there were 27 working days in August, while there were only 25 in September. The statistics do not include the Detroit, Toledo & Ironton, which had not yet filed its report.

Surplus Serviceable Cars

The freight car surplus continued to increase during the weeks ended December 15, 23, January 8 and 15, according to the Car Service Division of the American Railway Association, the totals reported for these periods being 371,221, 404,214, 496,357 and 439,982 cars, respectively.

Bad Order Cars

According to reports compiled by the Car Service Division of the American Railway Association, the total of bad order cars showed a decrease during the period ending December 15 to 308,556 or 13.5 per cent, as compared with 14 per cent on December 1.

Labor Board Decisions

WAGE INCREASE TO PAINTERS.—In a complaint by the United Brotherhood of Maintenance of Way Employees and Railway Shop Laborers against the Delaware, Lackawanna & Western, the Board held that painters were entitled to an increase of 15 cents an hour as specified in decision No. 2 and as covered in paragraph B of decision No. 92, effective March 1, 1920.—*Decision No.* 518.

CARPENTERS REFUSE TO AID IN STRIKE DUTY.—Three carpenters on the Pennsylvania Railroad refused to work on bunk cars required by railroad police during the outlaw switchmen's strike in April, 1920. In a case involving the pay of these carpenters for the time not employed during the strike, the Labor Board held that the men were not entitled to it.—*Decision No.* 517.

Examination for Locomotive Inspectors

The United States Civil Service Commission announces an open competitive examination for inspectors of locomotives on March 8 and 9, 1922. Vacancies in the Bureau of Locomotive Inspection of the Interstate Commerce Commission at salaries of $3,000 a year and in positions requiring similar qualifications will be filled from this examination. Applications for the examination should be made on Form 1892 which can be obtained from the Civil Service Commission, Washington, D. C.

American Society of Mechanical Engineers

The Executive Committee of the Railroad Division announces the following action taken at a meeting on December 28: James Partington, former secretary of the division, has been elected to the Executive Committee in place of George W. Rink, who has found it necessary to resign.

A. F. Stuebing has been elected secretary of the division in place of Mr. Partington.

W. H. Winterrowd was elected vice-chairman to succeed Mr. Rink.

William Elmer, of Altoona, Pa., has been added to the Membership Committee of the division.

An invitation from the Metropolitan Section has been accepted to hold a joint meeting with them in the Engineering Societies' building, New York City, on May 16, 1922. The subject of this meeting will be Railroad Refrigeration—Natural and Mechanical.

Reclamation Savings on the Rock Island

The Chicago, Rock Island & Pacific has effected a saving of $1,301,970 through its general reclamation plant at Silvis, Ill., during the three years ending with 1920. From each ton of scrap the company was able in 1918 to reclaim $6.75 worth of useful material, the entire saving for that year amounting to $467,947; in 1919, $8.10 in value was reclaimed from each ton of scrap, and the year's saving was $473,623; in 1920, $6.07 represented the value gained from each ton and $360,398, the total amount saved during that year. The amount and value of the material reclaimed at the general reclamation plant is steadily decreasing, according to C. H. Rost, general storekeeper, because of the work of committees on each division; a large amount of the reclamation work is now done locally. While the savings have thus been increased, no definite figures have been compiled to show the total secured in this manner.

Long Runs of Passenger Locomotives on the M. K. & T.

What is believed to be the longest regularly assigned run in the United States for steam passenger locomotives was inaugurated by the Missouri, Kansas & Texas on November 6, as a result of 11 months' experience in operating its oil burning locomotives in through runs of 400 miles each between Denison and San Antonio, Tex. Oil fuel having recently been adopted on the line between Denison, Tex., and Parsons, Kan., the plan has been adopted of operating trains No. 5 and No. 6, two of the heaviest on the line, with a single locomotive each way between San Antonio and Parsons, a distance of 678 miles. These

trains regularly handle from 10 to 12 cars and frequently are required to handle extra cars. They have been operated on time since the establishment of the long runs. Formerly, the locomotives were changed on these trains at Denison, Tex., and five locomotives were required to handle the runs. Under these conditions, the locomotives made a daily average of 266 miles each. Under the present plan, three locomotives are required to handle these runs, each making a daily average of 452 miles. Proper care of the locomotives at the terminals is considered the most important factor in insuring the success of the long runs, and in this case each locomotive has a minimum of 12 hours time at each terminal. The locomotives are required to take on fuel only once en route.

Shop Construction

ILLINOIS CENTRAL.—This company has awarded a contract for the construction of a car repair shed at McComb, Miss., to Ellington-Miller Company, Chicago. The building will be 600 ft. by 176 ft., with concrete foundation and steel superstructure, and with a cement tile roof. The entire cost is estimated at $140,000.

MISSOURI, KANSAS & TEXAS.—This company has given a contract to the Graver Corporation, Chicago, for the construction of a type "K" ground operated water treating plant at Parsons, Kan. The plant will have a treating capacity of 50,000 gal. of water each hour and a storage capacity at top of main settling tank capable of holding 200,000 gal. of treated water.

MISSOURI PACIFIC.—This company has awarded a contract to T. S. Leake & Co., Chicago, for the construction of a 25-ft. extension to its roundhouse at Hoisington, Kan.

MISSOURI PACIFIC.—This company has awarded a contract for the construction of a frame freight and passenger station at Zeigler, Ill., and the remodeling of a brick roundhouse at Coffeyville, Kans., to J. D. Fitzgibbon, St. Louis, Mo.

VIRGINIAN.—This company has awarded a contract to the Federal Engineering Company, Chicago, for the installation of a heating plant in its new roundhouse at Elmore, W. Va., to cost $15,000.

Passenger Cars

THE LONG ISLAND has ordered 40 motor cars for electric service and 10 steel coaches for steam service from the American Car & Foundry Company.

THE CHICAGO & NORTH WESTERN has given an order for 44 steel passenger cars, 3 combination baggage and smoking cars and 3 chair cars, to the American Car & Foundry Company.

THE CHICAGO, BURLINGTON & QUINCY has placed orders for 62 passenger cars and 12 dining cars with the Pullman Company and for 53 baggage and mail cars, with the Standard Steel Car Company.

Freight Car Repairs

THE CENTRAL OF GEORGIA is having a number of steel hopper cars repaired at the shops of the Chickasaw Shipbuilding Company.

Freight Car Orders

THE BANGOR & AROOSTOOK is applying steel underframes to 250 box cars in its shops at Derby, Me.

THE CENTRAL OF GEORGIA has ordered 500 box cars from the Mt. Vernon Car Manufacturing Company.

THE NATIONAL RAILWAYS OF MEXICO have ordered 250 tank cars from the General American Tank Car Corporation.

THE NEW YORK, CHICAGO & ST. LOUIS has ordered 300 steel underframe stock cars from the Illinois Car & Manufacturing Company.

THE NORTHERN REFRIGERATOR CAR COMPANY, Milwaukee, Wis., has ordered 500 refrigerator cars from the Haskell & Barker Car Company.

THE ATLANTIC COAST LINE will build 50 box cars at its Waycross, Ga., shops and is inquiring for steel superstructures and steel underframes for these cars.

THE ILLINOIS CENTRAL has placed orders for 2,000 gondola cars as follows: Haskell & Barker Car Company, 700; Western Steel Car Company, 400 and Standard Steel Car Company 400, all these cars to have 8 drop doors, and American Car & Foundry, 500 cars to have 12 drop doors.

THE SEABOARD AIR LINE reported as inquiring for prices on 1,500 ventilated box cars of 40 tons capacity; 200 flat cars with steel underframes of 40 tons capacity, and 300 steel phosphate cars of 50 tons capacity, has given an order to the Chickasaw Shipbuilding Company for some of these cars.

THE UNION PACIFIC has awarded contracts for 4,500 cars as follows: 1,000 all-steel automobile cars to the Pullman Company; 1,000 steel frame automobile cars to the General American Car Company, and 500 of the same type to the Standard Steel Car Company; 1,000 box cars each to the Mount Vernon Car & Manufacturing Co., and the American Car & Foundry Company.

MEETINGS AND CONVENTIONS

The American Society for Steel Treating will hold a sectional meeting Friday, March 3, at the Engineering Societies' building, New York City.

The following list gives names of secretaries, dates of next or regular meetings and places of meeting of mechanical associations and railroad clubs:

AIR-BRAKE ASSOCIATION.—F. M. Nellis, Room 3014, 165 Broadway, New York City. Annual convention May 9, 10, 11 and 12, Hotel Washington, Washington, D. C.

AMERICAN RAILROAD MASTER TINNERS', COPPERSMITHS' AND PIPEFITTERS' ASSOCIATION.—C. Borcherdt, 202 North Hamlin Ave., Chicago.

AMERICAN RAILWAY ASSOCIATION, DIVISION V—MECHANICAL.—V. R. Hawthorne, 431 South Dearborn St., Chicago. Next annual convention June 14 to 21, 1922, Atlantic City, N. J.

DIVISION V—EQUIPMENT PAINTING DIVISION.—V R. Hawthorne, Chicago.

AMERICAN RAILWAY ASSOCIATION, DIVISION VI.—PURCHASES AND STORES.—J. P. Murphy, N. Y. C., Collinwood, Ohio.

AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—R. D. Fletcher, 1145 E. Marquette Road, Chicago.

AMERICAN SOCIETY FOR TESTING MATERIALS.—C. L. Warwick, University of Pennsylvania, Philadelphia, Pa. Annual meeting Chalfonte Hotel, Atlantic City, N. J., beginning June 26, 1922.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Calvin W. Rice, 29 W. Thirty-ninth St., New York. Railroad Division, A. F. Stuebing, 2201 Woolworth Building, New York.

AMERICAN SOCIETY FOR STEEL TREATING.—W. H. Eisenman, 4600 Prospect Ave., Cleveland, Ohio. Sectional meeting, March 3, 29 W. 39th St., New York. Annual convention and exposition September 25 to 30, 1922, Detroit, Mich.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.—Joseph A. Andreucetti, C. & N. W., Room 411, C. & N. W. Station, Chicago, Ill.

CANADIAN RAILWAY CLUB.—W. A. Booth, 53 Rushbrook St., Montreal, Que. Regular meeting second Tuesday in each month, except June, July and August, at Windsor Hotel, Montreal.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—Aaron Kline, 626 N. Pine Ave., Chicago, Ill. Meeting second Monday in month, except June, July and August, New Morrison Hotel, Chicago, Ill.

CAR FOREMEN'S ASSOCIATION OF ST. LOUIS.—Thomas B. Koeneke, 604 Federal Reserve Bank Building, St. Louis, Mo. Meetings first Tuesday in month except June, July and August, at the American Hotel Annex, St. Louis, Mo.

CENTRAL RAILWAY CLUB.—H. D. Vought, 26 Cortlandt St., New York, N. Y. Meeting second Thursday in January, March, May, August and November, Hotel Iroquois, Buffalo, N. Y.

CHIEF INTERCHANGE CAR INSPECTORS' AND CAR FOREMEN'S ASSOCIATION.—W. P. Elliott, T. R. R. A. of St. Louis, East St. Louis, Ill.

CINCINNATI RAILWAY CLUB.—W. C. Cooder, Union Central Building, Cincinnati, Ohio. Next meeting February 13. General discussion, moving pictures and musical entertainment.

DIXIE AIR BRAKE CLUB.—E. F. O'Connor, 10 West Grace St., Richmond, Va.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—W. J. Mayer, Michigan Central, 2347 Clark Ave., Detroit, Mich.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—J. G. Crawford, 702 East Fifty-first St., Chicago, Ill. Next annual meeting Auditorium Hotel, Chicago, May 22 to 25, 1922.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—William Hall, 1061 W. Wabasha Ave., Winona, Minn.

MASTER BOILERMAKERS' ASSOCIATION.—Harry D. Vought, 26 Cortlandt St., New York, N. Y. Next annual convention Hotel Sherman, Chicago, May 23 to 26, 1922.

NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic Ave., Boston, Mass. Next meeting February 14. Paper on Organization and Modern Handling of Package Freight Through Freight Houses will be presented by G. Marks, assistant general manager, N. Y., N. H. & H.

NEW YORK RAILROAD CLUB.—H. D. Vought, 26 Cortlandt St., New York, N. Y. Next meeting March 17. Illustrated talks by F. M. Whyte on Railroad Conditions in Australia.

NIAGARA FRONTIER CAR MEN'S ASSOCIATION.—George A. J. Hochgreb, 623 Brisbane Building, Buffalo, N. Y.

PACIFIC RAILWAY CLUB.—W. S. Wollner, 64 Pine St., San Francisco, Cal. Next meeting February 9. Papers will be read by women employees detailing their experiences as chief exchange operator, agent, private secretary, welfare worker, etc. Motion pictures showing the manufacture of locomotive boiler tubes will be shown.

RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 515 Grandview Ave., Pittsburgh, Pa. Regular meetings fourth Thursday in each month, except June, July and August, at Fort Pitt Hotel, Pittsburgh, Pa.

ST. LOUIS RAILWAY CLUB.—B. W. Frauenthal, Union Station, St. Louis, Mo.

TRAVELING ENGINEERS' ASSOCIATION.—W. O. Thompson, Marine Trust building, Buffalo, N. Y.

WESTERN RAILWAY CLUB.—Bruce V. Crandall, 14 E. Jackson Boulevard, Chicago. Regular meetings third Monday in each month, except June, July and August.

PERSONAL MENTION

GENERAL

C. B. COLLETT, who has been appointed as chief mechanical engineer of the Great Western (England) succeeding G. J. Churchward, C. B. E., who has retired from that position, served his apprenticeship with Maudslay Son & Field, of London, and entered the service of the Great Western Railway in 1893 at Swindon as draughtsman. He subsequently filled the position of chief draughtsman and was appointed in 1900 technical inspector of the Swindon locomotive works. In 1901 Mr. Collett was appointed assistant works manager and in 1913 was promoted locomotive works manager. He has acted as deputy chief mechanical engineer since May, 1919.

WM. N. NELSON, mechanical engineer of the Minneapolis, St. Paul & Sault Ste. Marie, with headquarters at Minneapolis, Minn., has been appointed mechanical engineer of the Kansas City Southern, with headquarters at Pittsburg, Kan., succeeding E. P. O'Connor, assigned to other duties.

C. T. RIPLEY, general mechanical inspector of the Atchison, Topeka & Santa Fe, with headquarters at Chicago, has been promoted to the newly created office of chief mechanical engineer, with the same headquarters. H. H. Lanning, assistant mechanical engineer, with headquarters at Topeka, Kan., has been promoted to mechanical engineer with the same headquarters.

MASTER MECHANICS AND ROAD FOREMEN OF ENGINES

C. H. CREAGER has been appointed road foreman of engines of the Baltimore & Ohio with headquarters at Washington, Ind., and S. A. Rogers has been appointed to a similar position with the same headquarters.

JOHN J. HERLIHY, general foreman at Parkersburg, Ohio, has been appointed division master mechanic of the Baltimore & Ohio with headquarters at Washington, Ind. Mr. Herlihy was born on March 5, 1884, at Shelby, Ohio, and on January 1, 1902, entered the employ of the Baltimore & Ohio as a machinist apprentice at Newark, Ohio. After serving as a machinist at Newark, he was transferred to Cleveland, Ohio, where he first worked as a foreman, then as a machinist. On January 25, 1909, he resigned and became erecting and fitting foreman of the Erie Railroad at Cleveland, being promoted later to general roundhouse foreman at Youngstown. On October 2, 1911, he returned to the B. & O. as assistant roundhouse foreman at Newark, serving subsequently as machine shop foreman at Newark; general foreman at Cleveland; general foreman at Wheeling, W. Va.; acting master mechanic at Benwood, W. Va.; general foreman at Wheeling; general foreman at Benwood; assistant division master mechanic at Pittsburgh, Pa.; master mechanic at Parkersburg, and general foreman at Parkersburg.

W. G. MCPHERSON, master mechanic of the Regina division of the Canadian Pacific, with headquarters at Regina, Sask., has been transferred to Moose Jaw, Sask.

C. H. NORTON has been appointed master mechanic of the Susquehanna and Tioga divisions of the Erie.

J. C. RAE, general foreman of the Ann Arbor, with headquarters at Owosso, Mich., has been appointed acting master mechanic, with the same headquarters, assuming charge of the mechanical department, which action was necessitated by the resignation of J. E. Osmer, superintendent of motive power and the car department.

J. E. STEVENS has been appointed master mechanic of the Mobile & Ohio, with headquarters at Murphysboro, Ill., succeeding B. A. Orland, assigned to other duties.

F. A. Toates has been appointed assistant road foreman of engines of the Los Angeles division of the Southern Pacific with headquarters at Los Angeles, Cal.

SHOP AND ENGINEHOUSE

Roy Skidmore, erecting foreman of the Kansas City Southern, with headquarters at Pittsburg, Kan., has been promoted to shop superintendent with the same headquarters, succeeding Charles E. Oakes, deceased.

CAR DEPARTMENT

R. N. DODGE, senior inspector car equipment of the Interstate Commerce Commission, Bureau of Valuation, has been appointed car foreman in the heavy freight repair shop of the Chicago & Alton at Bloomington, Ill. Mr. Dodge was born in Champaign County, Ill., on March 19, 1882, and in 1898, after receiving a high school education, entered the employ of the Big Four as a car repairer at Urbana, Ill. In 1900 he moved to Danville, Ill., accepting service with the Chicago & Eastern Illinois. Two years later he was transferred to Dolton, Ill., and after about four years' service in the Chicago district as car inspector, joint inspector and assistant car foreman, he became car foreman of the Chicago, Milwaukee & Gary at Rockford, Ill., being promoted to general car foreman in 1906. Mr. Dodge served with the Interstate Commerce Commission from September, 1914, until October, 1921, during which time he traveled over a great many railroads, including some of the principal lines of the United States, making extensive inspections and studies of general conditions of car equipment, maintenance, construction and all conditions relative to serviceability, for the purpose of the federal valuation of railroads.

R. N. Dodge

PURCHASING AND STORES

G. W. BICHLEMEIR, purchasing agent of the Union Pacific with headquarters at Omaha, Nebr., has been promoted to general purchasing agent with the same headquarters.

ROBERT J. ELLIOTT has been appointed purchasing agent of the Northern Pacific, with headquarters at St. Paul, Minn. Mr. Elliott was born at Louisville, Ky. He entered railroad service in March, 1892, as a clerk in the accounting department of the Northern Pacific. Later he was transferred to the general manager's office, and after serving the company in various capacities he was in 1905 promoted to general storekeeper, with headquarters at St. Paul, Minn. In 1907, he was appointed assistant purchasing agent, with the same headquarters, which position he held at the time of his recent promotion.

R. J. Elliott

J. F. MCAULEY has been appointed division storekeeper of the Portland division of the Southern Pacific, with headquarters at Portland, Ore., succeeding H. J. Smith, who has become chief clerk to the general storekeeper at San Francisco, Cal., succeeding G. M. Betterton, promoted. J. Neph, storekeeper of the San Joaquin division, with headquarters at Bakersfield, Cal., has been transferred to the Los Angeles division, succeeding J. H. Collins, deceased. He will be succeeded by J. F. Brown, storekeeper of the Shasta division, with headquarters at Dunsmuir, Cal., who will be succeeded by F. L. Doss.

I. S. Fairchild has been appointed storekeeper of the New Orleans Terminal division of the Illinois Central with headquarters at New Orleans, La.

E. Gardner Thorpe has been appointed general storekeeper of the Long Island, succeeding Eugene Wright, promoted.

E. Griffiths, division storekeeper of the Chicago, Milwaukee & St. Paul, with headquarters at Perry, Iowa, has been transferred to Mobridge, S. D., succeeding G. L. Juel, who has been transferred to Malden, Wash., succeeding H. R. Meyer, who has been transferred to Perry to succeed Mr. Griffiths.

F. G. Prest, who has been appointed director of purchases of the Northern Pacific, with headquarters at St. Paul, Minn., was born on a farm near Queenston, Ont., on January 5, 1854. He entered railroad service on August 1, 1880, as a clerk in the purchasing department of the Northern Pacific at St. Paul. One year later he was appointed chief clerk of that department, which position he held until 1891, when he was promoted to assistant purchasing agent, with headquarters at St. Paul. In 1896 he was promoted to purchasing agent with the same headquarters and continued in that capacity until his promotion as director of purchases.

F. C. Prest

Joseph J Bennett has been appointed purchasing agent of the Illinois Central, with headquarters at Chicago. Mr. Bennett was born at Centralia, Ill., on July 7, 1885. He entered railroad service in 1902, as an expense clerk in the local freight office of the Illinois Central at Centralia. In 1903 he left to enter the employ of the Centralia Coal Company, for which company he worked in various capacities at the mines, and was later promoted to top superintendent. In July, 1907, he re-entered the service of the Illinois Central as coal inspector at Centralia. He was promoted to traveling coal inspector, Southern lines, with headquarters at Princeton, Ky., in March, 1909, and to fuel agent, with headquarters at Chicago on October 10, 1910. On January 1, 1913, Mr. Bennett was promoted to assistant purchasing agent, with the same headquarters, which position he was holding at the time of his recent promotion.

Joseph J. Bennett

C. B. Tobey, assistant general storekeeper of the Lehigh Valley, with headquarters at Packerton, Pa., has been promoted to general storekeeper, with the same headquarters, succeeding C. C. Huntington, who has left the service due to ill health.

OBITUARY

J. H. Collins, division storekeeper of the Southern Pacific, with headquarters at Los Angeles, Cal., died of pneumania on December 4, at his home in that city. Mr. Collins had been in the service of the Southern Pacific since 1906.

SUPPLY TRADE NOTES

The Keller Pneumatic Tool Company, Grand Haven, Mich., recently changed its corporate name to William H. Keller, Inc.

The Interstate Car Company, Indianapolis, Ind., is planning the erection of a one-story foundry for the production of iron castings, estimated to cost approximately $25,000.

The Pilliod Company, manufacturer of the Baker locomotive valve gear, has opened a western office at 750 Railway Exchange building, Chicago, in charge of Burton Mudge, vice-president.

S. F. Bowser, founder and president of S. F. Bowser & Co., Fort Wayne, Ind., has retired from the presidency of the company and will be succeeded by S. B. Bechtel, general manager.

William J. Cleary has been appointed assistant general sales manager of the Sharon Pressed Steel Company, Sharon, Pa. Mr. Cleary's headquarters will be in the Dime Bank building, Detroit, Mich.

The Streets Company, Chicago, which has heretofore confined itself largely to the construction and repair of wooden freight cars, has issued an inquiry for certain equipment for the manufacture and repair of steel cars.

William J. Armstrong, assistant treasurer of the Gould Coupler Company, New York City, died suddenly on December 25, at his home in Brooklyn. Mr. Armstrong had been in the service of the Gould Company for the past 25 years.

Albert J. Leonard has been appointed eastern sales representative of the Handlan-Buck Manufacturing Company, St. Louis, Mo. Mr. Leonard's headquarters are at the eastern office of the company, 52 Vanderbilt avenue, New York City.

The firm of Black-Matthews Company, Inc., 25 Church street, New York City, has been organized by Edward J. Matthews and J. Nelson Black to transact business in iron and steel products, together with machinery and railway equipment.

E. R. Mason has been appointed eastern and export representative of Brown & Co., Inc., Wayne Iron & Steel Works, Pittsburgh, Pa. Mr. Mason's headquarters are at the New York City offices of Brown & Co., Inc., room 2038 Grand Central Terminal.

The Youngstown Equipment Company has taken a contract to operate the Kent (Ohio), shops of the Erie Railroad. Webster W. Warner, superintendent of shops, has resigned his position with the railroad to become manager for the equipment company.

B. B. Milner, formerly engineer motive power and rolling stock of the New York Central, who for the past year has been with the Frazar importing-exporting interests, is returning to the Orient where he will establish his own practice as consulting sales engineer.

W. F. Cremean, representative at New York, of the Wine Railway Appliance Company, Toledo, Ohio, has been appointed sales engineer, with headquarters at Toledo, and Peter P. Beck succeeds Mr. Cremean as eastern representative, with office in the Grand Central Terminal, New York City.

Howard J. Charles, formerly with the purchasing and engineering department of the Union Pacific, at New York, who entered the service of the Elvin Mechanical Stoker Company, in June, 1921, has been appointed assistant treasurer of the latter company, with office at 50 Church street, New York City.

O. M. Rau, formerly consulting engineer of the Philadelphia Rapid Transit Company, is now associated with the Hardinge Company, New York City, specializing in the handling of pulverized fuel systems as applied to boilers, and W. O. Renken has been appointed managing engineer of the recently acquired Quigley pulverized fuel department.

The Pressed Steel Car Company and Western Steel Car & Foundry Company have discontinued their Washington, D. C., office. L. O. Cameron, who has been a representative of these

companies in the Southern territory for many years, has severed his connections with these companies, but will continue his office in the Munsey building to handle other accounts.

E. H. Dewson has retired as district engineer of the Westinghouse Air Brake Company, Wilmerding, Pa., in the Eastern territory with headquarters at New York City and will henceforth serve the company in a consulting or advisory capacity. J. C. McCune, assistant district engineer at New York, has been appointed district engineer to succeed Mr. Dewson. E. H. Dewson has been with the Westinghouse interests since 1901, when the old Standard Brake Company was acquired by Mr. Westinghouse and moved to Wilmerding, Pa., to be known as the Standard Traction Brake Company. Mr. Dewson had been chief engineer of the Standard Brake Company, a position which he retained under the new management. Several years later the engineering departments of the several Westinghouse companies at Wilmerding were consolidated, the Standard Traction Brake Company changing to the Westinghouse Traction Brake Company and Mr. Dewson became assistant chief engineer of the united organization. When the district organizations of the Westinghouse Air Brake Company were created, Mr. Dewson was named resident engineer for the Eastern district, embracing New England, New York, New Jersey, Eastern Pennsylvania, Maryland and Delaware. He has since remained in this position with headquarters in New York City. He has been closely identified with many important improvements in the air brake field during the last quarter of a century and is especially well known for his intimate knowledge of operating problems and traffic conditions in the city of New York. Mr. Dewson now resides at Quincy, Mass., where he plans to spend most of his time while enjoying the greater leisure which his new position will afford. Joseph C. McCune, who succeeds Mr. Dewson as district engineer of the Eastern territory, is his former assistant. Mr. McCune received his early training under the late W. V. Turner, and has held positions of importance in the Westinghouse organization for a number of years. He joined the Westinghouse Air Brake Company after graduation from Cornell University in 1911. He served through the war as an officer of engineers, acting as an instructor in the Third Officers Training Camp at Camp Lee, Va., and later saw service in France as a member of the Expeditionary Forces. He will maintain his present headquarters in New York City.

E. H. Dewson

J. C. McCune

C. W. Johnson, formerly of the Charles W. Johnson Lumber Company, Seattle, Wash., has been elected vice-president of the Duncan Lumber Company, Portland, Ore., and will be in charge of general operations. C. D. McCoy, formerly sales manager of the company, has been elected a vice-president and will be in charge of the eastern sales of the company, with headquarters in the McCormick building, Chicago.

W. H. Graul, department sales manager, and J. J. Hughes, manager of the order department of the American Steel Foundries, Chicago, have organized the firm of Hughes & Graul, manufacturers representatives, with headquarters in the Peoples Gas building, Chicago. The company will represent the Ohio Steel Foundry Company, Lima, Ohio, cast steel manufacturers, and the McConway & Torley Company, Pittsburgh, Pa.

Burton Mudge, president of Mudge & Co., Chicago, dealers in railway specialties, Chicago, has been elected vice-president and a director of the Pilliod Company, New York City, manufacturer of Baker locomotive valve gear, which duties he will assume in addition to those with Mudge & Co., Mr. Mudge was formerly connected with the operating departments of the Atchison, Topeka & Santa Fe, the Chicago & North Western, the Fort Worth & Denver City, and the Rock Island. He resigned as assistant to the general manager of the last named road in 1908, to enter the railway supply business and in September of that year organized the firm of Burton W. Mudge & Bro., representing the Commonwealth Steel Co., this company later becoming Mudge & Co.

Burton Mudge

Harry Barrett Marshall, who for 13 years served as manager of the St. Louis branch of The Electric Storage Battery Company, Philadelphia, Pa., has been placed in charge of all railway sales work of the company. Mr. Marshall, who will be located at Philadelphia, has been associated with the company for the past 16 years. He graduated from the Armour School of Technology in 1905, and a few months afterwards, joined The Electric Storage Battery Company serving in a clerical position at the Chicago branch. In 1909, he was appointed manager of the St. Louis branch, which position he held until his recent appointment in charge of all railway sales work. From the beginning of his association with the company, Mr. Marshall has devoted considerable time to the question of railway sales.

H. B. Marshall

The personnel of the executive staff of the Bridgeport Brass Company, Bridgeport, Connecticut, is now as follows: F. J. Kingsbury, chairman of the board; Carl F. Dietz, president and general manager; W. R. Webster, vice-president; F. J. Kingsbury, treasurer; R. I. Neithercut, secretary; W. D. Blatz, general sales manager; W. R. Clark, general works manager; E. G. Oakley, works manager fabricating division, and Arthur Brewer, works manager mill products division.

R. C. Campbell, formerly vice-president of the Duncan Lumber Company, has been appointed manager of the car and railroad material department of the Burton-Beebe Lumber Company, Seattle, Wash., with headquarters at Chicago. Mr. Campbell will also handle long leaf yellow pine for J. H. Burton & Co., Inc., of New York and Mobile, Ala. The Burton-Beebe Lum-

ber Company has moved its Chicago office from 53 West Jackson Boulevard to the Lumber Exchange building.

The Texas Company, New York City, has consolidated its traffic and railway sales departments into one department known as the railway traffic and sales department. The headquarters of G. L. Noble, vice-president; Wm. Jervis, manager, and W. E. Greenwood, assistant manager, is at 17 Battery Place, New York City, which will also be the headquarters of J. E. Symons, superintendent of the lubricating division. W. H. Barrows has been appointed district manager at Houston, Texas.

The Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., announces a number of changes and transfers in personnel in its railway sales department, the organization of which is now as follows: F. H. Shepard, director of heavy traction; M. B. Lambert, manager; E. D. Lynch, office manager; F. F. Rohrer, assistant to manager in charge of contracts; C. H. Long, section manager railway equipment contracts and orders; R. Seybold, manager price section; T. H. Stoffel, electric railway freight haulage export; W. R. Stinemetz, manager, and R. W. Carter, assistant manager of the heavy traction division; K. A. Simmon, manager, light traction division; J. L. Crouse, manager and J. W. Lewis, assistant manager, railway development and supply division; H. A. Campe has been appointed manager of the small motor appliance section of the industrial department, succeeding V. M. Beeler, who has been transferred to the Springfield office. H. B. Smith has been appointed manager of the domestic service section of the department, succeeding Mr. Campe and G. L. Washington has been appointed to manager of the Havana, Cuba, office.

John M. Weir has resigned as chief engineer of the Kansas City Southern, to become general superintendent of construction of the National Boiler Washing Company, Chicago. Mr. Weir was born in Ireland on July 31, 1879. He entered railway service with the Illinois Central in June, 1899, as a track apprentice and after occupying various positions, was promoted to resident engineer in charge of construction in March, 1907. Later he was concerned for a time with the construction of a small railway in Canada. After completing this work he returned to this country and entered the service of the St. Louis-San Francisco as assistant engineer at Springfield, Mo. Subsequent to 1908, he was made assistant engineer in the chief engineer's office in charge of construction of the Gainesville & Northwestern in Georgia and not long thereafter he entered the valuation department of the Chicago, Rock Island & Pacific. He served this company as assistant engineer of track of the Chicago terminal and as assistant engineer in charge of terminal valuation. In June, 1916, he was appointed division engineer of the Kansas City Southern, with headquarters at Pittsburg, Kan., and was promoted to chief engineer in March, 1917.

Superheater Company Forms French Connection

Geo. L. Bourne and Fred A. Schaff, president and vice-president, respectively, of the Superheater Company, New York, have recently returned from Paris, where they have formed as a French connection the Compagnie des Surschauffeurs, which has been given full rights for the sale and manufacture of the "Elesco" superheaters and forged return bends controlled by the Superheater Company.

This new French company brings together interests prominently associated with superheating in France, the board of directors being Ad. Seghers, A. Fiedler, S. Magis, Capt. F. R. Fitzpatrick and Geo. L. Bourne. Capt. Fitzpatrick will represent the American interests in the company, and will reside in Paris as a resident director. Ad. Seghers, has, for 20 years, been identified with superheating in France. A. Fiedler represents the Basse Loire group, comprising the Usines Métallurgiques de la Basse-Loire, Société des Forges et Aciéries du Nord et de l'Est, Ateliers et Chantiers de Bretagne, etc., and is, himself, managing director of the L'Auxiliaire des Chemins de Fer & de l'Industries, manufacturers of the Caille Potonie feed-water heater, high temperature pumps, etc. A. Magis is a member of the firm of Magis et Dumortier of Brussels, dealers in railway supplies.

The Compagnie des Surchauffeurs is located at 11 Rue Scribe, Paris, France. A plant has been established in the outskirts of Paris for the manufacture of all types of superheaters where the forged return bends will be made.

TRADE PUBLICATIONS

PRODUCTION TOOLS.—Three four-page leaflets, describing and illustrating Go & Go types of half side, plain and inserted tooth mills, have recently been issued by the Goddard & Goddard Company, Detroit, Mich.

LOCOMOTIVE AIR BRAKE GAGES.—The Ashton Valve Company, Boston, Mass., has issued Circular No. 66 describing and illustrating its improved 5 in. dial quadruplex air brake gages; also its triplex air brake and train signal gage.

FUEL SYSTEMS.—Sectional drawings of Quigley fuel systems and descriptions outlining methods of preparing, transporting and burning pulverized fuels are contained in Bulletin No. 12 recently issued by the Hardinge Company, New York City.

FLEXIBLE COUPLINGS.—Specifications, sizes, prices and dimensions, also considerable useful information, are included in Bulletin No. 32 which the Francke Company, Newark, N. J., has recently issued describing and illustrating its flexible couplings for direct connected machines.

ARC WELDING.—The Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., has recently issued Leaflet 1825 describing and illustrating arc welding as applied to repair and reclamation work. General applications of arc welding for manufacturing processes are included.

HYDRAULIC VALVES AND FITTINGS.—Sixty-four pages of illustrations, descriptions, tables and helpful information are contained in Catalogue 43B which the Hydraulic Press Manufacturing Company, Mount Gilead, Ohio, has recently issued covering its line of high pressure valves and fittings.

AIR BRAKE INSTRUCTION PAMPHLETS.—The Westinghouse Air Brake Company, Wilmerding, Pa., has issued new editions of its instruction pamphlets covering the No. 6 ET locomotive brake equipment, the UC passenger car brake equipment and the 3T triple valve test rack and codes of tests.

WIRE AND WIRE ROPE.—The development of wire by John A. Roebling and its use in the construction of bridges, especially the Brooklyn bridge, cables and cableways, hoisting devices, aeroplanes, etc., are described in an interesting manner in "Outspinning the Spider," written by John Kimberly Mumford and published in book form by the Robert L. Stillson Company, New York City.

PUMPS.—A booklet explaining what is meant by trade pumps, plain fitted pumps, or brass fitted pumps; what is considered standard equipment for a trade pump and what the manufacturer considers as extras, has recently been published by the Hydraulic Society, New York City. Typical sizes of trade pumps are also shown and definitions given of the terms used in the industry, such as static head, total dynamic head, suction lift, static suction lift, dynamic suction lift, etc.

THERMOSTAT TEMPERATURE REGULATING SYSTEM.—The Gold Car Heating & Lighting Company, Brooklyn, N. Y., has recently issued its 1921 catalogue describing an electric thermostat temperature regulating system for the automatic control of steam, hot water or hot air heating apparatus. The booklet shows the various types of thermostat control for all kinds of heating equipment. Complete diagrams are given showing the location of the apparatus, as well as the actual connection between the thermostat, motor and furnace.

CHIMNEY LOSS.—Two new bulletins of the combustion and the cost of power series have recently been issued by the Uehling Instrument Company, Paterson, N. J. Bulletin No. 220, discussing the magnitude of the power plant's chimney loss, contains diagrams showing the great importance of the chimney loss as compared with other boiler losses, also the possible improvements in efficiency at average boiler plants. Bulletin No. 221, outlining the relation between CO_2 and heat units wasted up the chimney, contains a diagram showing the saving in dollars per year per 100 boiler horsepower by increasing the per cent CO_2 in the flue gases, also tables showing the per cent of losses for solid, liquid and gaseous fuels.